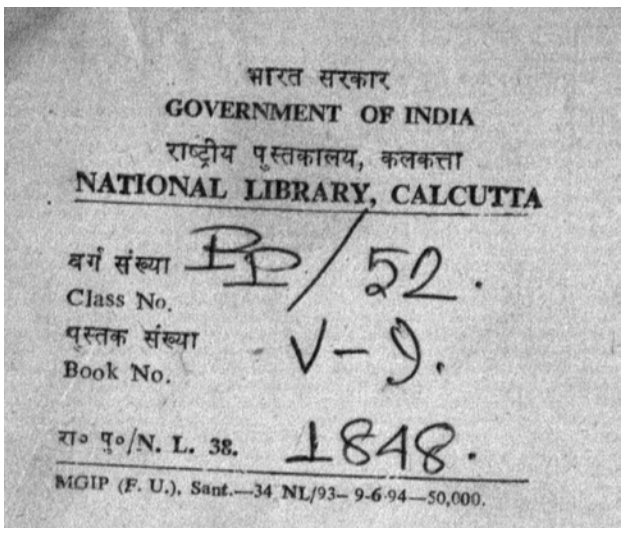
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MGIP (F. U.). Sant.—34 NL/93—9-6-94—50,000.

THE

CIVIL ENGINEER AND ARCHITECT'S JOURNAL,

SCIENTIFIC AND RAILWAY GAZETTE.

VOLUME XI.

1848

LONDON:

R. GROOMBRIDGE AND SONS, 5, PATERNOSTER ROW; J. WEALE, 59, HIGH HOLBORN; WILEY AND PUTNAM, NEW YORK; GALIGNANI, AND MATHIAS, PARIS.

Printed and Published by WILLIAM LAXTON, the Proprietor, at No. 10, Fludyer Street, Whitehall.

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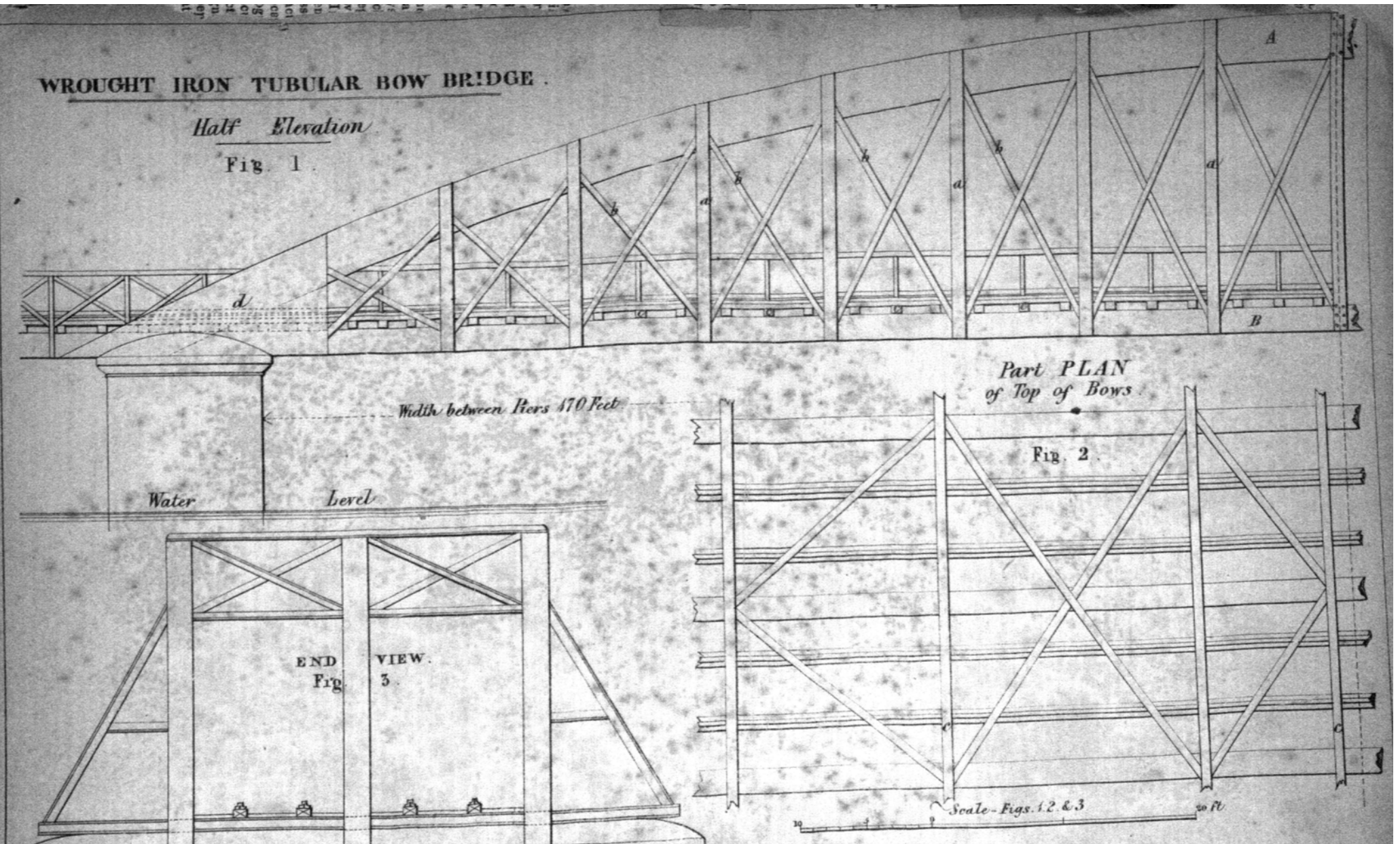
WROUGHT IRON TUBULAR BOW BRIDGE.

Half Elevation

Fig. 1.



Part PLAN of Top of Bows

Fig. 2.

Fig. 3.

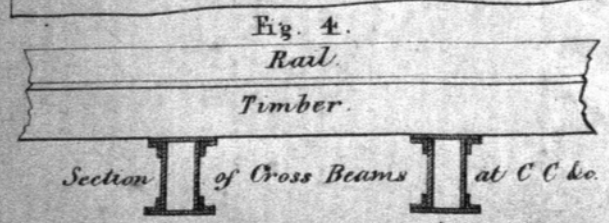


Fig. 4.

Scale to Figs. 4 & 5. ½ pr. ft.

SECTION *of Arch at A.*

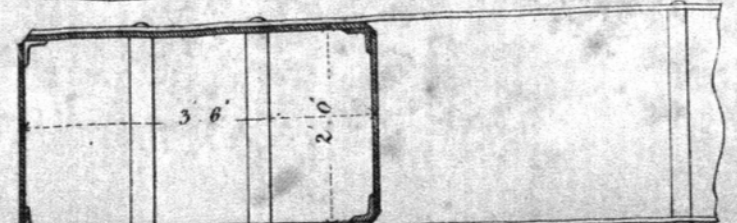
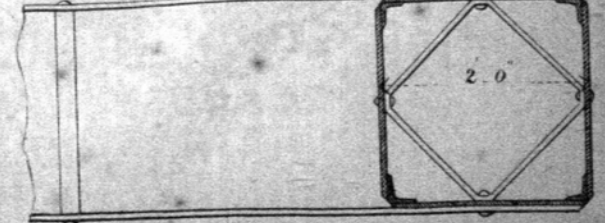


Fig. 5.

SECTION *of Arch at B.*



C. Hagster.

THE

CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

WROUGHT-IRON TUBULAR BOW BRIDGE.

(With an Engraving, Plate I.)

In consequence of the tubular form becoming a favourite mode of constructing bridges of wrought-iron for railway purposes, we are induced to give an engraving of a wrought-iron tubular bow suspension bridge for crossing the Ouse river in Norfolk, designed by Mr. W. C. Harrison, who has had considerable experience in the construction of some large timber bow suspension bridges on some of the Norfolk railways.

Mr. Harrison observes,—"The facility with which a bow bridge of this construction, with boiler-plate, could be put together, appeared so evident, that he felt convinced of its practicability and usefulness for railway purposes, in crossing rivers and valleys, to almost any extent. A bridge of this kind could be easily put together, by the same kind of workmanship as in steam boilers, in a manufactory in any part of the country, and in certain convenient lengths of 10, 15, or 20 feet each, for the purpose of transporting to its destination, so that there will be but a few joints to rivet up when put in its place. The bow being hollow, and also the tie-beam, or string as it may be termed, gives the opportunity for a man to get inside to hold up the rivets for the workmen outside to rivet the parts together.

"The bow and string are to be made of plate-iron, of such a thickness as is most suitable to the size of the bridge intended to be constructed, and joined at the angles with angle-iron; and it will be perceived from the engraving how perfectly well connected the extreme ends of the tie-beam and bow will be by the manner shown, which is a plate extending over the tie and bow, firmly rivetted to each, thereby answering the purpose of an abutment to the bow, and giving perfect security in a vital part.

"The elevation of the bridge shows both the suspending and cross-brace bars, being all of plate-iron, from the facility of getting bars in this shape so easily made, and requiring so little workmanship—namely, the rivet holes made in their ends.

"The design is for a span of 170 feet and two lines of rails; consequently, there are three bows. Fig. 1 is the elevation of one-half the span, with the suspending bars *a a* and *b b*; *d d*, the abutment plates, as they may be called; *c*, the cross-beams, which may be of iron or timber. Fig. 2, a view on the top of the bows, with some of the cross-beams, *c*, extending outside (as also seen at fig. 3, the end elevation), to receive the lower ends of the struts going up to the top of the outside of the bows, to give steadiness to the whole; but these can be used or not. Fig. 3 shows the distance-pieces and cross-frames between the bows. Fig. 4 is a section of the cross-beams or girders, which may also be made of wrought-iron plate and angle-iron, or wood, to carry the timber sleepers of the rail. Fig. 5 is an enlarged section of the bow and string, and the distance-piece between the suspending bars."

Mr. Harrison proposes for a bridge of the span shown in the engraving, that the bow should be constructed of half-inch plate-iron, 4 feet deep by 3 feet wide; and the tie-beam or stringer 2 ft. 6 in. deep by 3 feet wide.

Next month we will endeavour to offer some remarks on the construction of bridges of the tubular form, as to their applicability for railway purposes.

A DEFLECTION OR VIBRATION GAUGE.

By George Howard Fenwick, C.E.

The accompanying engraving, fig. 1 (drawn to one-third the full size), is a gauge for registering the vibration or deflection of railway girders. A is a piece of wood or metal, made to slide in another piece, B, which is held in position by a slight pressure of two springs, G and F, as shown on plan fig. 2 (drawn full size). On the face A are two arrows at C, which can be moved to any of the holes at D for adjustment. It is supposed to be set at zero, and as it receives the pressure from the girder E it is pressed down, thereby registering the deflection of the girder on a decimal or mechanical divided scale on B. This gauge may be applied by being supported by a frame let into the sides of the walls which the girders span, and so made to travel to any particular place, such as the centre or springings; or may be placed upon a staff for convenience, similar to a levelling staff.

G. H. F.

[This simple and ingenious contrivance might, perhaps, be improved by fixing a vernier on the slide D, divided so as to indicate the hundredth parts of an inch; the side scales being divided into inches and tenths.]—Editor.

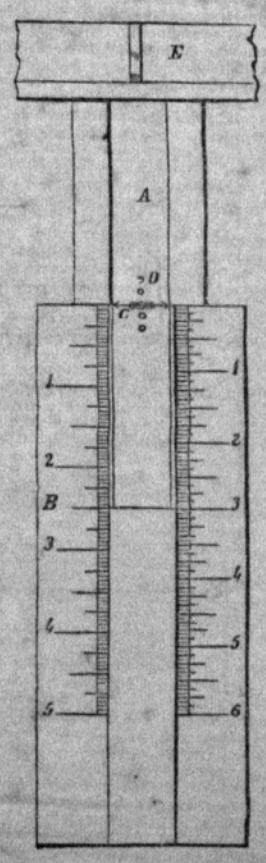


Fig. 1, Elevation.

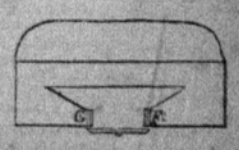


Fig. 2, Plan.

NOTES ON ENGINEERING.—No. VIII.

By HOMERSHAM COX, B.A.

On the most Economical Forms of Suspension Bridges.

Of all kinds of bridges suspension bridges are capable of being constructed with the greatest span. Notwithstanding this advantage and the facility of construction, the use of these structures has been restricted by their flexibility and tendency to undulate. They have fallen into disrepute in the modern practice of engineering, on account of the difficulty (generally deemed insuperable) of making them sufficiently rigid for the purposes of heavy traffic, such as that upon railways. Another, though less obvious, objection is that the ordinary methods of calculating the proper form and dimensions of suspension bridges, and the different strains to which they are subjected, are exceedingly complicated. The intricacy of the investigations leaves a degree of uncertainty and distrust as to the actual strength which the several parts of a suspension bridge may be assumed to possess.

The object of the present paper is to examine how far these difficulties may be removed, and to show what method of arranging the different parts of the structure secures the greatest amount of strength for the whole.

Suspension bridges may be distinguished generally into two classes: 1st., those of the ordinary form, that of a main chain or catenary, with the roadway suspended from it by vertical rods; 2nd., those in which the roadway is suspended directly from the abutments by straight rods, the catenary or curve chain being altogether dispensed with. It will be shown, on strict statical principles, that the first method involves a great waste of material, and that, by a proper arrangement of *straight* rods, a given amount of strength may be secured with a smaller quantity of iron, or a greater amount of strength with a given quantity of iron, than by the use of a main catenary. Of course, methods of using straight rods may be employed which involve greater waste of material than even the employment of the curved chain. The most economical arrangement of straight rods is not a merely arbitrary matter, but depends, like every other branch of engineering, on sound deductions from the laws of mechanics.

Before proceeding with the investigation, it may be as well to remind the reader that the object of these Notes on Engineering is to simplify the practical applications of theory, and to explain them, as far as possible, in familiar, untechnical language. This important rule should be constantly remembered by all who teach and all who study the mathematics of engineering—*that long formulæ are never put into practice.* In practice, simple general principles are far more useful, because capable of being applied with far more certainty and facility, than the most elaborate results of scientific research.

We now proceed to establish the following important general

PROPOSITION.—*In a suspension bridge the material required to sustain a given load will be the least when each point of support in the roadway is directly connected with a point of suspension in the nearest abutment by one independent straight rod.*

To begin with the simplest case, it will be first of all supposed that only two points of support in the roadway are connected with the point of suspension. Suppose that B (fig. 1) is the point of

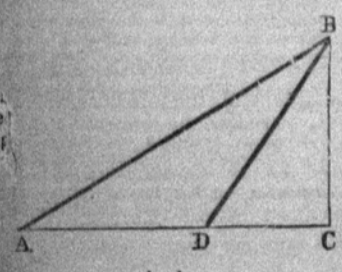


Fig. 1.

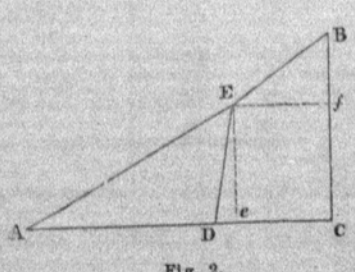


Fig. 2.

suspension; A and D the two points of support in the horizontal platform A C. Then it will be shown that to sustain a given load, the most economical arrangement of the suspension bars consists in connecting B with A D independently and directly by two rectilinear rods, A B and D B. If, however, as in fig. 2, the connection be *indirectly* made by suspension rods meeting at an intermediate point E, more material will be required for a given amount of strength.

In order to prove this proposition, which has so important a relation to the most usual methods of constructing snspension bridges, it is necessary to ascertain the quantities of material in the rod A B and B D (fig. 1), and the rods A E, D E, and B E (fig. 2), and to compare the aggregate amount of material used in both cases. It is, of course, presupposed that the strength of the rods is proportioned to the strain upon them. In ascertaining the thickness to be given to the rods of a suspension bridge, the first point to be settled is the amount of strain which the material will bear on each square inch of the sectional area. For the purpose of mere *comparison*, it is indifferent what amount be assumed: it may therefore be supposed that the rods are to be calculated to bear a strain or tension of t lb. per square inch of their sectional area. Consequently, multiplying the sectional area of any rod by t, we have the whole strain to which it is subjected. Further, for purposes of comparison it is indifferent what be the load on the bridge, so that in both cases the weights at corresponding points of the platform be supposed the same: let it therefore be assumed that both in fig. 1 and fig. 2 the point A has to sustain a vertical weight w, and also (for the sake of simplicity) that the point D in both figures has to sustain the same weight w.

It will (at first) be taken for granted that the platform contributes nothing by its rigidity to sustain the load; that the whole weight is borne by the suspension rods, which are kept in their oblique position by the connection of the platform. The amount of material requisite to support w at the point A will first be considered.

Commencing with the case of fig. 1, we have, since the rod A B sustains the weight w at A, the vertical component of the tension of A B equal to w. Supposing the sectional area of this rod to be k square inches, its tension, by what has been already said, will be kt.

$$\therefore w = kt \sin BAC = kt \cdot \frac{BC}{AB}; \quad k = \frac{w}{t} \cdot \frac{AB}{BC}.$$

Consequently, the mass of the rod = its sectional area multiplied by its length $= \frac{w}{t} \frac{AB^2}{BC}$ ..... (1).

Proceeding now to the case of fig. 2, and still confining attention to the suspension of the point A, by reasoning exactly the same as that for fig. 1, the mass of the rod $AE = \frac{w}{t} \frac{AE^2}{Ee}$, (E$e$ being drawn vertical.)

It is clear that the connection between the point B and the point E may be supposed to be established, not by a simple bar, but by a compound bar of two or more parallel lengths. In fact, this method is that usually adopted in actual practice, the several links of the chain commonly consisting of several bars or iron plates laid side by side, and connected at their extremities. Their relative thickness is a matter of indifference, provided that the total thickness be sufficient to sustain the strain. In fig. 2 the rod B E, provided it have the thickness necessary to sustain the united effects of the two weights at A and D, may be supposed to be made up of any number of parallel bars of any relative thickness whatever. Now, supposing B E to be a compound bar, let k' be the sectional area or thickness of metal due to the effect of the weight at A, k'' the thickness due to the weight at D: $k' + k''$ will be the total thickness of B E.

Taking the thickness k' to be that requisite to sustain w at A, and $k't$ the consequent amount of tension of that part of the compound bar, we have the vertical component of $k't$ (= vertical component of tension along A E) $= w$. Hence, if Ef be drawn horizontal, $w = k't \sin BEf = k't \frac{Bf}{EB}$, $\therefore k' = \frac{w}{t} \frac{EB}{Bf}$.

Multiplying this quantity by the length E B, and adding the mass of the rod ascertained above, we have the total mass of metal required to connect A and B $= \frac{w}{t} \left\{ \frac{AE^2}{Ee} + \frac{EB^2}{Bf} \right\}$ ..... (2)

Hence subtracting the expression (1) from the expression (2), it will be easily found by some simple analysis, which is here omitted for the sake of brevity, that the mass required for the indirect connection A E B, fig. 2, exceeds the mass required for the direct or rectilinear connection, A B fig. 1, by a quantity

$$\frac{(BC \cdot Ef - AC \cdot Ee)^2}{BC \cdot Bf \cdot fC} \cdot \frac{w}{t},$$

which is positive in all cases. Hence, more material is always required for the indirect than for the direct connection of A and B.

The same mode of reasoning applies to the weight suspended at D.

The form of the analysis is such that it applies to this case as well as the last, and leads to a similar conclusion—that the indirect or bent connection, D E B, requires more material than the direct or rectilinear connection, D B. Now it is evident, that what is true of the several parts of the system individually, is true of the whole collectively—that if less material be required for each of the direct connections than for each corresponding indirect connection, the total material required for all the former will be less than the total material required for the whole of the latter. In other words, *the system of suspension in* fig. 1 *is the most economical.*

The same result might have been obtained by supposing B E a simple, undivided bar, and the amount of material given by that hypothesis would be the same as that on the hypothesis here adopted. But the method of investigation given above leads more easily to the general results for which we are seeking. It has the advantage of admitting immediately, and without any more mathematical analysis, the following important

Corollary.—*The method of suspension* (fig. 1) *is more economical than the method* (fig. 2), *for* any *number of points of support in the platform.*

For the reasoning given above is not affected by supposing the rod B E to divaricate at E into three or more radial bars proceeding to as many points of support in the roadway. Whatever might be the number of indirect connections by this method, each of them would require more material than the corresponding direct connection of fig. 1: and therefore the total quantity of metal required by the former method exceeds the total quantity required by the latter method.

We have hitherto considered, in the second or indirect method, only one point of divarication, E: the inquiry will be completed by considering several other such points to exist—as at B, B′, B″, B‴, &c., fig. 3.

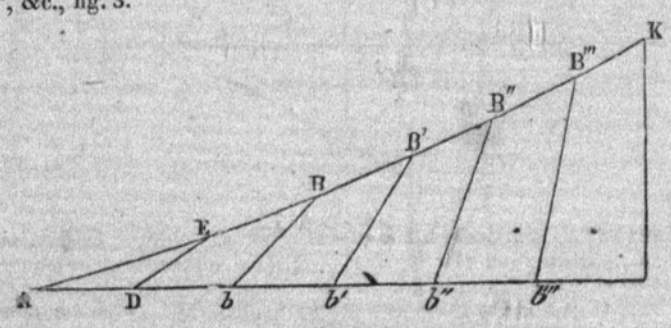


Fig. 3.

The connection of A and D with B, by bars meeting at E, has been already considered. Less material would have been required to support the weight at A and D, if, instead of the method shown in fig. 3, there had been separate straight rods from A and D to B. In this latter case, B′ (the next point of suspension) would be connected with the *three* points A, D, *b*, by three straight rods, divaricating from the end B of a common rod B B′.

The "Corollary" given above shows that this triple divarication involves a waste of material. Had there been in the place of it, three straight rods from A, D, and *b*, to B′, less material would have been required to support the corresponding weight. But this triple divarication itself requires less material than the method shown in fig. 3. Hence, *a fortiori*, the direct connection with B′ would require still less material than the method shown in the figure. And so, by continuing the same mode of reasoning for the other points, B″, B‴, &c., we come at last to the general conclusion that, if all the points of support had been directly and independently connected with K (the ultimate point of suspension), less material would have been required to sustain given loads than by the method shown in fig. 3.

This conclusion is independent of the inclination of the rods E D, B*b*, B′*b*′, B″*b*″, &c., and remains true when they are vertical. Hence, in the common suspension bridges, such as those at Charing-cross, Hammersmith, &c., with a main chain or catenary hanging between the abutments, and connected with the platform by vertical rods, there is a waste of material. The same conclusion applies to all suspension bridges having radial bars radiating from any point except the points of ultimate suspension at the abutments—and, therefore, hold with respect to the bridges on Dredge's principle, some of which are erected in the Regent's-park, and of which one recently gave way and was destroyed near Calcutta.

The amount of saving effected by connecting all the points in the platform with the abutments by independent straight rods, may be best shown by an example. The Hungerford bridge, at Charing-cross, may be taken as a familiar example—and we will, therefore, proceed to compare the material required for that bridge by the method actually adopted, and the quantity which would be required by the method here advocated.

The quantity of material required for suspending the bridge by a catenary and vertical rods will first be considered. The position of the centre of gravity of the half-span depends on the form and weight of the chain, and the manner in which the load is distributed along the platform. When the load is small compared with the weight of the chain, the centre of gravity of half the bridge and load will be nearer the abutment than the centre of the bridge: for the curvature of the chain, its increase of thickness near the point of suspension, and the increased length of the vertical rods, all tend to make the weight preponderate towards the abutment. But when the bridge is supposed to be loaded with a breaking weight greatly exceeding the weight of the chain, and uniformly distributed along the platform, it may be assumed, without sensible error that the horizontal distribution of the weight of the *whole* system is uniform. In this case, the centre of gravity of the half-span will be midway between the abutment and centre of the bridge.

At this latter point the tension of the catenary is horizontal. Let moments be taken about the point of suspension for the equilibrium of the half-span: then, since the horizontal tension in question acts below the point of suspension, at a vertical distance equal to the deflection of the chain, and since the weight acts at a horizontal distance from the same point equal to the quarter-span, the products of each of these forces into the corresponding distance will, by the Principles of Moments, be equal. Hence, calling W the total weight of the half-span (including the half-chain), T the horizontal tension, d the deflection, a the quarter-span,—it follows that

$$W a = T d; \quad \text{or } T = W \frac{a}{d} \ldots\ldots\ldots\ldots\ldots\ldots (1).$$

That is, *the horizontal tension = the weight of the half-span multiplied by the ratio of the quarter-span to the deflection;* a simple rule, from which the horizontal tension of the chain of any suspension bridge loaded with its breaking weight may generally be calculated with sufficient accuracy.

It has been assumed that the load is uniformly distributed, or that any portion of the weight is proportional to the length of the corresponding portion of the platform. It follows, that if any distance, x, be measured along the platform from the lowest point of the chain, the weight corresponding to that distance is $W \frac{x}{2a}$.

Also, if y be the vertical ordinate of the chain at the same distance, a known principle which applies to catenaries of every form gives

$$\frac{dy}{dx} = W \frac{x}{2a} \div T = \frac{W x}{T 2a} \ldots\ldots\ldots\ldots (2)$$

By another known principle which also applies to all kinds of catenaries, the tension at the point (x, y) is equal to

$$T \cdot \left(1 + \frac{dy^2}{dx^2}\right)^{\frac{1}{2}}.$$

And since the sectional area of the chain at any point is supposed proportional to the strain at the same point, we have, if K and k be sectional area at point (x, y), and the lowest point of the chain respectively

$$K = k \left(1 + \frac{dy^2}{dx^2}\right)^{\frac{1}{2}}.$$

The mass of each small portion of the length of the chain is the product of that element of length, and the corresponding sectional area: hence it will be easily seen that the

$$\text{mass of the half-chain} = k \int_0^{2a} \left(1 + \frac{dy^2}{dx^2}\right) dx.$$

And this quantity by substitution from (2) will be found equal to $2ak \left(1 + \frac{W^2}{3T^2}\right)$. Finally, if the tension per square inch be t, and consequently $T = kt$, and if a be put = 170 feet, and $d = 50$, it will be readily ascertained that the

$$\text{mass of the half-chain} = \frac{w}{t} \times 1189{\cdot}3.$$

(which are almost exactly the values of those quantities in the Hungerford Bridge.)

To obtain the whole quantity of material required for the purposes of suspension, we must add to the quantity last obtained, the

mass of the suspension rods. The length of these increases from the centre to the abutment, and is equal to that of the vertical co-ordinates of the catenary.

The integration of equation (2) gives the relation of y to x, which will be found such that *the proportion between any two vertical co-ordinates is equal to the square of the proportion between the corresponding horizontal co-ordinates*—a very simple rule for determining the form which the chain will nearly assume when subject to its breaking weight.

It follows from this rule, that when

x is	$\frac{1}{20}$ th	of the half-span,	y is	$\frac{1}{400}$ th	of the deflection,
x	$\frac{2}{20}$ ths	,,	y	$\frac{4}{400}$ ths	,,
x	$\frac{3}{20}$ ths	,,	y	$\frac{9}{400}$ ths	,,
x	$\frac{4}{20}$ ths	,,	y	$\frac{16}{400}$ ths	,,
	&c.	,,		&c.	,,

Now, if we suppose the half-platform attached to the half-chain at every 20th of the length of the former, we shall, by adding up all the y's in the above scheme, get the total length of all the vertical rods together, which, therefore, is equal to

$$\tfrac{1}{400}\,(1 + 2^2 + 3^2 + 4^2 + \ldots\ldots\ldots\ldots + 19^2) \times \text{deflection};$$

and this by actual calculation is equal to the deflection $\times$ 6·175. Therefore, since the deflection is 50 feet, the total length of all vertical rods is 308·75 feet. This supposes that the platform meets the chain at the centre, the value of y at that point being zero.

Each rod sustains one-twentieth of the weight of the half-span, and therefore has a tension $= \frac{1}{20}w$. Therefore, if, as before, t be the tension per square inch of the sectional area, that area, by principles already laid down $= \frac{1}{20}\frac{w}{t}$. The mass of all the rods equals this quantity $\times$ the length 308·75 feet, just obtained $= \frac{w}{t} \cdot 15\cdot\frac{4}{5}$.

Adding this to the mass of the half-chain, we have finally

the mass of the half-chain and its rods $= \frac{w}{t} \times 1204\cdot7$ .....(A).

Next, let it be ascertained what is the quantity of material required when the load is supported by straight rods exclusively. It has been shown that if $\frac{1}{20}w$ be sustained at A by a straight rod A B, the mass of that rod $= \frac{1}{20} \cdot \frac{w}{t} \cdot \frac{AB^2}{BC}$.

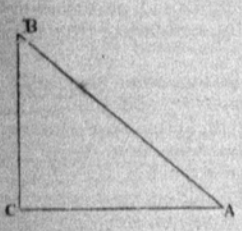


Fig. 4.

This expression (since A B C is a right angled triangle, and therefore $AB^2 = AC^2 + BC^2$,) is equivalent to $\frac{1}{20}\,\frac{w}{t}\left(\frac{AC^2}{BC} + BC\right)$. When

A C is	$\frac{1}{20}$ th	of the half-span,	$AC^2 = \frac{1}{400}(2a)^2$
A C	$\frac{2}{20}$ ths	,,	$AC^2 = \frac{4}{400}(2a)^2$
A C	$\frac{3}{20}$ ths	,,	$AC^2 = \frac{9}{400}(2a)^2$
	&c.		&c.

Adding up all the values of AC^2, we get for the total mass of the rods

$$\frac{1}{20}\,\frac{w}{t}\left\{(1 + 2^2 + 3^2 + \ldots\ldots 19^2)\,\frac{(2a)^2}{400 \cdot BC} + 19\,BC\right\} =$$

$$\frac{1}{20}\,\frac{w}{t}\left\{6\cdot175\,\frac{(2a)^2}{BC} + 19\,BC\right\} = \frac{w}{t}\,761\cdot3 \ldots\ldots\ldots\ldots (B).$$

Comparing the expression (B) with (A), we see that the material required in one case is about $\frac{7}{12}$ths of what is required in the other case. In other words, *if a suspension bridge, of the dimensions of the Hungerford bridge, were sustained by independent oblique rectilineal rods, instead of a main chain and vertical rods, a saving of nearly half the material would be effected.*

It will be hereafter shown, that great as is this advantage with respect to the power of the bridge to sustain a statical load uniformly distributed, still greater advantages belong to the method of suspension here advocated, when the effect of moveable loads is taken into consideration.

THE OBLIQUE ARCH.

On the Focus to which the Joints on the Face converge.

Suppose a right-angled plane triangle formed of any flexible material, having its two sides respectively equal to L, the axial length, and πr, the semicircle obtained by taking a section of the bridge perpendicular to the axis. If the side L be placed along the top of the abutment of an oblique bridge, and the triangle wrapped over the laggings, the hypothenuse will form a spiral line, which is the intersection of the coursing joints and soffit. If a straight line move along the axis of the cylinder, so as always to intersect it at right angles, and pass through the hypothenuse of the above triangle, it will generate the twisted surface proper for the beds of the stones. Mr. Buck was the first to show that the joints that appear on the face of the arch, pass through a point O, below the centre C, when the "section on the square," or section perpendicular to the axis, is a *circle*. A similar expression for the length of the line C O may be obtained when the sections of the intrados and extrados, made by a plane perpendicular to the axis, are similar ellipses.

Let the figure represent the elevation of an oblique bridge, circular or elliptic "on the square"—if it be segmental, the ellipses must be supposed completed. Take the axis of the cylinder for the axis of y, and let the plane xy be horizontal. A, B; a, b, are the semi-axes, major and minor, of the extrados and intrados respectively. A $\times$ E, $a \times$ E, the lengths of these semi-ellipses. S = arc A′P, where C N = A cos θ; and s = arc $a'p$, where C x = arc $a'p$. L = axial length. Ω = acute angle between the directions of the roads. Φ = angle of extrados; and, therefore, $\tan\Phi = \frac{AE}{L}$.

The equations to the extradosal and intradosal spiral are, respectively,

$$\left.\begin{aligned} X &= A\cos\Theta \\ Y &= \frac{L}{AE}S \\ Z &= B\sin\Theta \end{aligned}\right\} (1) \qquad \left.\begin{aligned} x &= a\cos\theta \\ y &= \frac{L}{aE}s \\ z &= b\sin\theta \end{aligned}\right\} (2)$$

and the equation to the face of the arch is $y = x\cot\Omega + d$. (3)

Let X′ Y′ Z′, x' y' z', be the co-ordinates of the points in which the corresponding extradosal and intradosal spirals meet the face of the arch. Then X′ Y′ Z′, x' y' z', are co-ordinates of a point in the face of the arch, and must satisfy equation (3).

$$\therefore Y' = X'\cot\Omega + d;\ \text{and}\ y' = x'\cot\Omega + d;$$

$$\therefore X' - x' = (Y' - y')\tan\Omega = \frac{L}{E}\left(\frac{S}{A} - \frac{s}{a}\right)\tan\Omega =$$

$$\frac{A}{\tan\Phi}\left(\frac{S}{A} - \frac{s}{a}\right)\tan\Omega.$$

In order to determine the length of CO, it will be sufficient to confine our attention to the projection on the plane xz, of a straight line passing through X′Y′Z′, $x'y'z'$. The equation to this projection is

$$z - Z' = \frac{Z' - z'}{X' - x'}\left(x - X'\right);$$

and if $x = 0$, $z = CO$, $\therefore CO = -\frac{Z'x' - z'X'}{X' - x'} =$

$$-\frac{B\sin\Theta\, a\cos\theta - b\sin\theta\, A\cos\Theta}{X'-x'} = -\frac{Aa\sqrt{1-e^2}\sin(\Theta-\theta)}{\frac{A}{\tan\Phi}\left(\frac{S}{A}-\frac{s}{a}\right)\tan\Omega} =$$

$$-b\cot\Omega\tan\Phi\,\frac{\sin(\Theta-\theta)}{\left(\frac{S}{A}-\frac{s}{a}\right)} = -b\cot\Omega\tan\Phi$$ nearly, since the difference of Θ and θ is always very small.

Hence, whether the "section on the square" be circular or elliptic, at the point b make the angle $fbC = 90-\Omega$; and at the point f, where bf meets Ca, make the angle $CfO = \Phi$, the angle of the extrados; the point O where fO meets bC produced is the focus to which the joints on the elevation converge. $CO = Cf\tan\Phi = CB\tan(90-\Omega)\tan\Phi = b\cot\Omega\tan\Phi$

If the section perpendicular to the axis be circular, f will be the focus of the ellipse $a'ba$, and may be readily found by describing from the centre b, with radius Ca, an arc of a circle which will cut Ca in f, the focus of the ellipse $a'ba$. If we had considered this case alone, the preceding calculations would have been much simplified, for then $A = B = R$; $a = b = r$; $AE = \pi R$; $aE = \pi r$; $S = R\Theta$; $s = r\theta$; and $CO = -r\cot\Omega\tan\Phi\,\frac{\sin(\Theta-\theta)}{(\Theta-\theta)}$.

The line fO may be readily and accurately drawn by setting off with any scale of equal parts fh = axial length, and erecting a perpendicular hk equal the semicircle or semi-ellipse in which a plane perpendicular to the axis cuts the extrados.

F. Bashforth.

CANDIDUS'S NOTE-BOOK.

FASCICULUS LXXVII.

"I must have liberty
Withal, as large a charter as the winds,
To blow on whom I please."

I. I must confess to being completely disappointed by Hay's book on the "Laws of Harmonious Colouring;" nor at all the less so for its having reached a sixth edition, when had reviewers reported of it conscientiously at first, its futility for any purpose of real instruction would have been pronounced long ago. It is not to be denied that it contains some useful information in regard to the colours—that is the pigments, employed in house-painting; which may have caused a demand for the book among the operatives in that humble branch of art. But as to any direct insight which it affords into the theory and principles of artistic colouring, as one main auxiliary to architectural design and effect, it is altogether null. Or, at the very best, it merely affords a faint glimmering here and there of something like approximation to the subject promised by the title-page. Possibly, Mr. Hay is fully capable of clearly explaining to others the doctrine which, it may be presumed, he has satisfactorily established for himself. Nevertheless, he has thrown very little, if any, light upon the matter. To say the truth, his book shows no disposition to communicate more than he can possibly help; in which respect, however, he is by no means singular, there being many other books of a similar description, in which the information is studiously concealed,—either evaded, or else wrapped up in oracular brevity, or in verbiage overclouded by more than oracular obscurity. Had Mr. Hay, instead of theorizing so much, *ins blanc*, as the Germans say, condescended to exemplify harmony of colouring in decoration by a few positive instances—both such as were distinguished for the observance, and others which proved its value by showing the errors arising from neglecting it—he would have supplied his readers with some really useful lessons; whereas now he leaves them entirely to themselves to take their chance for making out what he, as their professed instructor, should have carefully explained step by step Where he ought to have been most of all full and explicit, he is more vague and brief than elsewhere. On the other hand, he is somewhat loquaciously prolix in regard to the work done by him at Abbotsford, notwithstanding that it does not in the slightest degree serve to illustrate the Laws of Harmonious Colouring, the painting being there confined to the mere imitation of oak and wainscotting. In short, the book is a rather humbugging affair, for the light which Mr. Hay has thought proper to afford us amounts to no more than "darkness visible," and there he leaves us to grope about.

II. The fresco scheme for the decoration of the Palace of Westminster does not, it seems, answer expectation,—at least so does not what has been done in the House of Peers, where the experiment has been first of all made, instead of the artist acquiring proficiency in that mode of painting, by being employed in less important parts of the building before touching that which ought to display, not the efforts of "'prentice hands," but the mastery acquired by matured proficiency. Among other defects and oversights complained of, it is now discovered that, partly owing to the profusion of gilding and vivid colours of the other decorations, the frescoes do not produce the anticipated effect, they being in a great measure overpowered and eclipsed by what is mere embellishment. Thus they are in a manner converted from principal objects as works of art, into quite secondary ones as regards the general *ensemble*,—a serious defect, that will be further increased when all the windows shall have been filled with stained glass, whose brilliant hues will inevitably cause the frescoes to appear, by contrast, feeble and faded, more especially as the windows occupy so very large a proportion of surface. The only remedy which is now left, is to moderate the scheme of colouring for the windows, by executing them nearly entirely in chiaro-scuro, with only a few touches of positive colour here and there. Yet even this would be unsatisfactory in another respect, because such sparing application of colour in the glass would be out of keeping with the showiness in regard to colour of much of the ornamental work. The fact is, the decorations of the "House" have been studied only piecemeal, and those employed upon them have considered no more than their own particular share, without at all calculating the general effect. As far as the frescoes are concerned, it would surely have been easy enough to ascertain their effect beforehand, by filling in all the six compartments with the cartoons for the respective subjects. Yet, obvious and simple as such mode of preparatory trial was, it seems, somehow or other—perhaps owing to the fatality which hangs over all our public undertakings in art—to have been overlooked. Bold as it may be thought to say so, a determined system of blundering seems to be established for them. Certainly not the slightest pains are taken to prevent blunder, by proper experiment previous to the work being actually commenced. On the contrary, the chief precaution taken is to keep matters entirely in the dark, until some irreparable mischief has been committed; and the only satisfaction left us is to amuse ourselves by wondering that they should have been managed so perversely.

III. Of so-called religious subjects in painting, some are audaciously profane, others the most trivial in matter, and one and all equally fabulous; giving us only the fancies of artists for the representations of historical events. Religion may have been the patron of art, but art has been but a very questionable, if not positively treacherous, ally to religion. It served Popery during the middle ages, for the impostures of the one were in keeping with the impostures of the other. But for pure Christianity, art can do just as much and no more than it can for the advancement of pure mathematics. There is a great deal of very palpable and maudlin cant afloat in regard to religious art. Hardly were any of the great masters inspired; on the contrary, many of them were anything but exemplary in their lives, and exercised their pencils on the lewd traditions of pagan mythology with quite as much gusto as they did on the traditions of the Church. Mediæval art has, besides, contributed not a little to that fundamental superstition of popery, Monolatry, against which worship of the pretended "Queen of Heaven," the Salic law ought to be enforced amongst Catholics.

IV. Notwithstanding their piddling and minikin pedantry, architectural writers are apt to be exceedingly careless in their language, frequently employing expressions and terms after a truly nonsenical fashion. They will speak, for instance, of an order as being "of colossal *proportions*"! the proportions being all the while precisely those which are generally followed for the particular order in question. Of course, they mean "dimensions" or "scale;" therefore, to use the other term, betrays strange confusion of ideas and the meaning of words. Nothing, again, is more common than the truly barbarous solecism—one for which a schoolboy would be corrected as a dunce—of employing the term "Intercolumniation, not in its own proper sense, but in that of "Intercolumn;" which is nothing less than marring technical language, and doing away with those distinctions in it which are essential to its accuracy. If there be anything that can excuse such a truly vulgar blunder, it is the authority it receives from our architectural-dictionary-makers, some of whom among their other qualifications seem to have been totally ignorant of the languages from which most of the terms of the art have been borrowed for our own. The confounding together the terms "Intercolumniation" and "Inter-

column"—or rather the rejection of the latter altogether, notwithstanding they are quite distinct in meaning—is peculiar to English writers, those of other countries properly observing the distinction between them. Just as well might we use "Columniation" in the sense of "Column," and speak of a portico as consisting of so many columniations, as call "Intercolumns" "Intercolumniations"—the latter term signifying, not the actual *spaces* between the columns, but the *mode of spacing* adopted for the columns. The inaccuracy of language here corrected may be thought a fault of no consequence; yet, as it is just as easy, it is surely just as well to employ terms correctly as not; and the correctness thus recommended is surely also far less finical than that puerile affectation of antiquated orthography, which insists upon a final *k* in the word "Gothic," now invariably written "Gothick" by those who pique themselves upon their orthodoxy; the *k* serving as a badge of it—perhaps, like other badges, as a substitute for it.

V. If Bunning's design for the new Coal Exchange be not wickedly caricatured in a wood-cut of it that has been published, it must be a mortally queer one, still more queer than the Gothic exhibited by him in the City of London School, the taste displayed in which can be accounted for only by supposing that Guildhall diffuses an architectural malaria throughout the whole of that neighbourhood—a supposition rather confirmed than contradicted by the specimen of Italian at the corner of King-street.—To keep to the Coal Exchange, it seems the design of some architectural coal-heaver. I say "seems," for though it is made to appear such, it may prove the contrary; and that is all the more likely because, as has been shown, a good deal in it is utterly unintelligible. There is room, therefore, for suspecting that it has been greatly misunderstood and misrepresented. According to what, it is to be hoped, is a very gross caricature, Mr. Bunning's design is absolutely architecture run mad—madder than any of Borromini's freaks. In short, it is impossible to believe that such extravagant uncouthness and unmeaningness of forms as are there exhibited, will be actually perpetrated; therefore judgment ought to be suspended until the work shall have been executed. Still, it is difficult to conceive how such a degree of misrepresentation could have occurred. Surely the wood-cut in question must either have been taken from an exceedingly rough and random sketch indeed, or have been the work of some arrant bungler.

VI. A story is told of a lecturer who was cut short in a long-winded rambling preamble, consisting of truisms and commonplace dressed up in high-flown phraseology, by one of his auditory getting not only impatient, but also getting up and saying: "You will excuse the interruption, Sir, but I must beseech you to bear in mind that we have not come provided with nightcaps!" This sally was succeeded by such a grand chorus of laughter, that before it had subsided the unfortunate lecturer had thought proper to vanish. Like many other so-called anecdotes, the above may be pure invention, it being, perhaps, too good to be exactly true. Its *moral*, however, is a tolerably significant one, and deserves to be attended to. If it be not an Hibernianism to call that strange which is so generally practised, it might well be called strange that so much mere school-boy stuff should be served over and over again in lectures and written essays; sometimes to the exclusion of anything besides such frothy matter, it being poured in so unsparingly, that there is actually no room for what would be substantial and nutritious. Now, people may be excused for not knowing more than what is already familiar to every one at all acquainted with the subject professedly treated of; but there is no occasion for them to betray to others that such is really the case. It was not very long ago that conversing with an acquaintance who had been to hear some lecture upon architecture, he told me that little as he himself knew of the subject, he knew enough to be able to engage to produce something infinitely more to the purpose than what he had heard, it being utterly stale, and barren of the least fresh information; much of it consisting of mere metaphysical moonshine, better calculated to mystify than to enlighten the auditory.

VII. It may fairly be questioned whether sculpture for the pediment of the British Museum might not just as well be spared, inasmuch as such partial decoration will only serve to render the absence of ornament in the rest of the structure all the more painfully striking. Even without such addition to the main building, there is a most unartistic want of keeping between that and the wings,—a defect which it is now so utterly beyond the power of any mere ornamentation to remedy, that it is more likely to be increased by attempting it. At present it is not so apparent as it will be when the old buildings, which serve in some degree as a foil to the new ones, shall have been completely cleared away, and the entire line of the latter become fully exposed to view. What sort of a *tout ensemble* may easily enough be guessed, since it may even now be plainly foreseen. If there be any doubt at all in regard to it, it is only because it still remains to be seen how it is intended to inclose the court from the street. Should it be done by any such sort of palisading as that before the Post-office, the effect will be mean and tasteless in the extreme. Whatever it is to be, that and the sentry-boxes were probably not included in the model, which, it might reasonably be fancied, did not even so much as exhibit the wings, otherwise their incongruousness with the central structure could hardly have failed to be noticed and objected to by those to whom the model was submitted—at any rate, if they were at all qualified for exercising any judgment in the matter. One question not wholly undeserving deliberate consideration there is which does not seem to have occurred to any one, namely, whether it would not have been more advisable, instead of adhering to the arrangement of the original edifice to advance the new façade up to the street or nearly so, thereby extending the plan, by taking in the court-yard. That would have provided the accommodation that will in a few years be required, should the collections continue to increase as they hitherto have done. Much available space has also been thrown away elsewhere, since without entirely filling up the inner court, it was obviously practicable enough to occupy a portion of that quadrangle (317 and 238 feet) by one or more ground floor galleries within it, lighted from above, and not so high as to obstruct the windows towards the court, which are besides at a considerable height from the ground. Or the apartments there formed might have been on a somewhat lower level than the court itself. It will, perhaps, be said that should it be found requisite, this may still be done, but certainly not so well as it might have been, had it been planned at first, since it would call for some alterations in what is already built; besides which, had it been thought of at first, the cost of the inner façades of the quadrangle might have been spared, since plain brick walls—quite shut out of view, as they would have been—would have been just as well in such a situation as the present one faced with stone. Even had the court been partly built upon below, the upper part of it—that is, as much of its sides as could be seen from within through the windows, might still have been finished as at present, with the omission however of the columns and antæ, so that its general appearance as so viewed would have been quite as satisfactory as it is now; nor need buildings within the quadrangle have been at all visible from any of the surrounding galleries or other apartments.

VIII. The plan of the National Gallery was in a great measure sacrified to the unlucky and obstinately-persisted-in whim of letting St. Martin's church be seen from Pall-Mall East. Since it has been thrown open by the removal of the Mews, that building, said the wiseacres, must on no account be shut out of sight again as it was before; as if such would really have been the case were it not visible from Pall-Mall East, when it would have shown itself as well, or perhaps even better—more picturesquely than it does now, from Cockspur-street and Trafalgar-square. But for that stupid whim, which prevented the architect from bringing his portico at all forwarder than he did, and also compelled him to set back the extremities of his façade very considerably, the building might have been nearly twice as much in depth as it now is, and in some parts even more than that. It must be admitted that notwithstanding the disadvantages forced upon him, Wilkins might have arranged it much better, there being at present a great deal of space thrown away, that might by a little contrivance have been turned to good account. As to the dome, I have not a word to say in excuse of it, it being so decidedly bad. Excuse for Wilkins, upon the whole, there is much, for never, perhaps, was architect more worried and thwarted than he was in that unfortunate building.

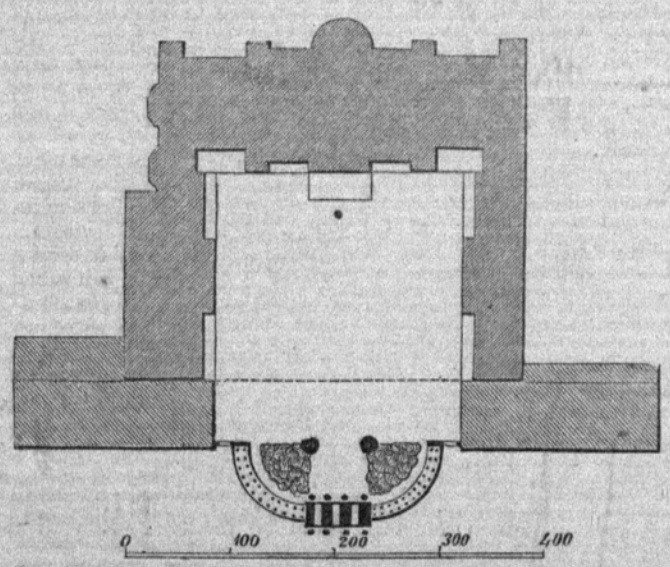
IX. "Eminent" must be an epithet of exceedingly doubtful meaning when we find it applied to an individual recently deceased, who, as an architect, was of no note whatever. However eminent Mr. * * * may have been *in* the profession, he was certainly not at all eminent *out* of it, his name being totally unknown to the public. Rather was he eminently obscure, since so far from being quoted in evidence of his talent, not a single building by him has ever obtained notice at all. As a man, he may have been a very worthy character: so he might, had he been an "eminent cheesemonger," in which case eminence and obscurity might have been allowed to go hand-in-hand together. Truly grievous is it that harmless nobodies should be so vilely daubed over as soon as they are dead. It looks too much like thanking them for going out of the world and leaving their snug places and appointments for others. The professional life of the eminent architect alluded to, would, I fancy, form a more curious than interesting contribution to the biography of artists.

BUCKINGHAM PALACE AND THE MARBLE ARCH.

But one opinion has been expressed of this unfortunate Palace, for if it finds favour at all with any, they have not the courage to utter so much as a syllable in defence of it. We may accordingly spare ourselves further censure of what is actually done, our present purpose being to point out what might have been done, and doubtless would have been, had aught like due or decent consideration been given to the matter, the idea here submitted being so very obvious a one that it is difficult to conceive how it could have by any possibility been overlooked. Or if it was not overlooked, but purposely rejected, it becomes desirable to know on what grounds it was set aside, since the reasons must have been more than ordinarily cogent ones to lead to its rejection.

Looking at the Palace as it stood before the alteration was commenced, no one would have ever imagined that the blocking it up by another building, merely in order to obtain additional rooms, and thereby depriving all the original portion of the building of those advantages of situation and prospect which in some degree atoned to its occupiers for its architectural deficiencies, would have been resorted to without all other expedients being first tried. The preserving the same view as before into the Park should have been made a *sine qua non;* instead of which Mr. Blore seems to have had a *carte blanche* to do just as he pleased, and he seems to have studied nothing more than merely providing the extra accommodation required, in an additional building merely tacked on to the first one. To say that he at all considered the circumstances of the case—the opportunity which it held out for architectural improvement, would be to accuse him of downright incapacity. The most prudent excuse for him is that he was called upon so suddenly to prepare drawings for the purpose, that he had no time to collect his thoughts, much less any ideas, those which he might else have had being put to flight by the expeditiousness imposed upon him. Whereas had he been allowed to apply himself to the task leisurely and quietly, he would have devised some means of preserving the Marble Arch, and not only retaining it, but giving it increased value and importance, as the focus point of a new façade.

General, vague suggestions of this kind, it will perhaps be said, are very easily made, but we here offer somewhat more than a mere shapeless, unembodied idea, by showing in the annexed cut



how the Arch could have been retained and connected with the advanced line of new buildings. We would have continued the stylobate and order of the Arch by two sweeping double colonnades (quadrant in plan). This would not only have given greater privacy to the court-yard, the stylobate being sufficiently high to prevent its being looked into, but would also have given it greater apparent space than before, when that space was so indistinctly defined by the palisading, that as seen from the Palace the Arch appeared to stand as quite a distinct and insulated object in the Park. According to the plan here shown, it would, on the contrary, in connection with the colonnades attached to it, have formed a highly scenic piece of architecture, full of play of light and shade and perspective effect, and admitting a view of the landscape scenery in the Park in the background. As an embellishment to the court there might have been parterres in the quadrant portions of it, with a fountain in the centre of each quadrant. To specify other matters of decoration not indicated in the plan—statues and candelabra for gas-burners placed alternately in the intercolumns of the colonnades, and a colossal sitting figure of Britannia on the summit of the Arch, giving to the latter what it has all along wanted, a pyramidal termination to its mass, would have produced a more than ordinarily striking architectural picture, whether viewed from the Palace or the Park. As seen from the latter, it would have been a sufficiently effectual screen to the buildings within the court, and after the sun had passed off from the east side of the Palace, would have been continually lighted up by its rays striking upon some of the columns during the whole day. In combination with additional buildings carried out to the right and left in extension of the original wings, such a colonnaded centre might have been made to produce a façade not at all inferior to, perhaps even more picturesque, than that of any other royal palace in Europe; whereas now—but we can hardly speak with decent patience of the miserable and truly contemptible abortion which Blore has perpetrated, both to his own disgrace, and the disgrace of those who employed him. Had such a design for enlarging the Palace been sanctioned by William IV., though our mortification would have been the same, our surprise would have been considerably less. His taste and feeling for art never extended beyond the figure-head of a ship. That it should have been perpetrated under the auspices—at least under the very nose of a Prince who affects the character of a connoisseur and patron of art, fills us not only with astonishment, but dismay. We account for it only by supposing that he was *overruled* in the matter, he being no more than Prince Consort.

To show, as we have, what might have been done, when the opportunity for doing it has passed away, may seem ungracious. Our reply is, it is no fault of ours that the opportunity was not afforded us, and not ourselves alone, but others also perhaps far more able, of making suggestions at a time when advantage might have been taken of them. At any rate, we hope that Buckingham Palace will now prove an efficacious lesson for the future; and it is also some consolation to find that it is not only poor, but so desperately bad, that there is very little danger of its corrupting public taste, because it will be now more mocked, and more an object of general derision than ever. Admiration it will excite none whatever, that's certain; but then it is equally certain that it will excite a vast deal of astonishment. It will completely astonish the natives, and all foreigners into the bargain.

As the Marble Arch—which might have been so easily retained, and not only retained but greatly improved, and made the nucleus of an extended piece of decoration in the foreground of an extended line of façade—is to be taken down, the question now is, is it to be destroyed, or re-erected on some other spot? Nobody except those actually in the secret, knows; though why it should be made a secret at all nobody can tell, unless it be because the intention in regard to it is so preposterous that were it divulged it would excite strong opposition. Our idea is that the street front of the Horse Guards would be a very suitable situation for it. It would there fill up what is now too much of a gap, and the two smaller arches would serve admirable as the recesses for the sentinels on horseback. It has, indeed, been rumoured that both the Horse Guards and Admiralty are to undergo architectural transformation by Mr. Barry. But instead of that interposing any obstacle, it would rather facilitate such application of the arch, since Barry would only have to bring it into his design, and treat the rest of the composition in accordance with such feature.

BUCKINGHAM PALACE.

Sir—It seems not a little singular that none of the critics who are disposed to animadvert in such severe terms on the new front of Buckingham Palace, not even your lynx-eyed "Candidus" himself, should have discovered that it is only a reduced copy (about two-fifths in length) of the Palace at Caserta; so that the faults or merits, be they which they may, are not Mr. Blore's, but Vanvitetti's. In proof of which, I beg your acceptance of tracings of the perspective view of the front and of the plan, after Vasi.

It is to be feared that the imitation will be confined to the part of Vanvitetti's design upon which he appears to have bestowed the least pains, that is the outside, and that there are but faint hopes of an equal imitation of the splendid staircase and vestibule.

Vasi states the length of the north and south fronts of Caserta to be 918 palms (Neapolitan, I presume), which, at 10⅓ inches

would give 873 ft. 10 in. for the length of the front. The east and west fronts, by the same reckoning, would be 618 ft. 10 in.; and, as the length of Buckingham Palace is stated in the *Journal* at 350 feet, the proportion is exactly two-fifths. The height of Caserta is 120 feet; of Buckingham Palace, 77 feet.

I visited Caserta thirty years ago, in company with Mr. Woods and M. Soiss, the eminent Belgian architect, and the notes of that day are now before me.

"The central passage or vestibule leading from the entrance is 24 feet wide, and 24 feet high to the springing of the semicircular vault. The steps of the middle flight of the stairs are 22 feet long, and the two return flights each 14 feet long (100 steps in all), and are of white and reddish variegated marble: there are statues, trophies, &c. The vestibule above is handsome, but (in my eyes at that time) in bad style. The chapel (which is opposite to the staircase) has coupled columns, of Sicilian marble. The lower part of the chapel is lined with slabs cut from the Giallo Antico columns, removed from Purruoli," &c. &c.

Let Mr. Blore give to the Palace a staircase at all resembling this, and the world will forgive him the faults of his front; many of which have, no doubt, been forced upon him, as upon his great predecessor, by the necessity of providing accommodation for so many people.

I have read Mr. Elmes's Epitome of the Lives of English Architects with great satisfaction, and beg to express my hope that he will carry out his "present intention" without delay. I would take the further liberty of suggesting to him that the illustrations he promises ought to consist mainly of unedited specimens, or at least of those of which the engravings are least accessible, or the works containing them least known. A list, referring to the books in which the most meritorious of each architect's productions are to be found, would be very valuable.

It should be remembered that size is not the criterion of merit. How many of us country architects are forced to take the counsel of our excellent friend, Percier, and in despair of executing large works, to bestow greater care upon lesser ones?

I am, &c.,

York, Dec. 13, 1847. ROBERT SHARP, Architect.

COWPER'S INVERTED ARCH BRIDGE.

SIR—In reflecting on the construction of Mr. Cowper's bridge, I think it is interesting to notice that the boiler plates are *rivetted together*, so that the pressure on the piers and abutments must now be *vertical* instead of *oblique*, as in the common suspension bridge.

Hence, then, in *principle* it may be said to coincide with the ordinary girder bridge, but its alteration in *form* suggests an important advantage, which it possesses; for, in the girder bridge (and especially when dealing with long bearings), there must always be this objection, viz., that by reason of the gravity of the material itself, independently of any additional influence of a load placed upon it, it is constantly tending to assume a curved form, and such curved form not being the natural position of its particles, it is constantly tending to rupture; but in the "inverted arch bridge" the material is thrown into that form (or nearly so) which it *would* take if perfectly *flexible*, and *then* is made perfectly *rigid*. So that, as regards its *own* gravity, there is no further alteration of form, of any practical importance, to be apprehended.

With regard to the alteration of form which might result from a load being put upon it, Mr. Cowper has already pointed out the preventive measure, viz., the giving to the vertical dimension of the plate such a magnitude as to bring the line of strain *within* the plates.

I think the name might have been more aptly chosen: "Inverted arch" is suggestive only of *form*, and not of *principle*, and might (it seems to me) with equal propriety be applied to the ordinary suspension bridge.

I am, &c.,

G. W. RICHARD.

*** It is not clear that it would be practicable to make the "inverted arch bridge" so rigid as to exert only vertical pressures on the abutments, and to act as a curved girder.

Suppose its span 200 feet and depth 4 feet, and that a weight of 30 tons (engine and tender) rests at its centre. Then, by the ordinary principles of statics which apply to girders, we may easily find the horizontal strains of tension and compression which this weight *alone* produces at the centre. Considering the half-structure as a separate statical system, the forces acting upon it have equal moments about the point of support in the abutment: or half the weight × the half-span = the moment of the couple of tension and compression created at the centre of the bridge. The length of the arm of couple is indeterminate, but (since the total depth is 4 feet) it is a favourable supposition to take it at 3 feet. Hence, calling the horizontal strain P, we have

$$P \times 3 = 15 \times 100, \text{ or } P = 500 \text{ tons!}$$

The metal must be tolerably thick to resist *five hundred tons* pressure on the upper, and tension on the lower, side of the bridge at its centre! This difficulty is formidable enough when the structure is considered as all one piece, but becomes insuperable when the effect of joints is taken into account, It is not to be overcome by any system of rivetting and dove-tailing, however intricate.

Though it be easy to calculate the amount of the horizontal strains at the centre of the curved beam, it is not easy to estimate the sectional or transverse dimensions necessary to resist those strains; for our knowledge of the transverse strength of wrought-iron is much less than of cast-iron. Some idea may, however, be obtained from analogy. The "inverted arch," if it sustains itself by its rigidity as a girder, may, for all purposes of calculating the strength at its centre, be considered as a horizontal beam 200 feet long and 4 feet deep, with an effective width of 1 foot to 1 foot 6 inches at the utmost. Now, the proposed Menai tubular bridge will be 450 feet long, but its depth will be *thirty feet*, and width *fifteen feet*: also its upper and lower sides will be composed of several thicknesses of metal, as the former will consist of two, and the latter of one, series of cellular compartments. The analogy between the Menai bridge and the inverted arch is complete in several respects: both are tubular, both are to be composed of rivetted wrought-iron plates, and both are designed for railway traffic. The sectional dimensions of the Menai bridge are suggested by actual experiment, and are never considered too great. Is it not, therefore, abundantly evident that a beam of $\frac{2}{3}$ths the span of the Menai tube, but with only an eighth or twelfth its depth and width, would not be rigid enough to sustain itself as a beam?

If suspended from, instead of resting upon, the abutments, it might perhaps be prevented from actually falling, but it would certainly bend. If the point of suspension be supposed to be at the upper edge of the end of the beam, the transverse strains of deflection will be somewhat reduced by the curvature of the beam; but it would be difficult to show that this advantage would not be far more than compensated for by the increase of length, and therefore of material, which the curvature renders necessary,

It is important to remark, that if the *only* requisite for security were that the depth of the chain should "include any alteration in the curve of the strain," that depth should not be uniformly 4 feet. It should be *nothing* at the centre of the span and the point of suspension, and gradually increase up to some intermediate part. The highest and lowest points of a catenary may be always chosen arbitrarily.

The argument that the chain would not be distorted because it is "of such depth as to include any alteration in the curve," is vague and inconclusive. It certainly cannot stand ground against deductions from the fundamental equations of statical equilibrium. The reasoning given above is a simple, ordinary application of the elementary principles of mechanics; these are not to be opposed by a mere hypothesis, which is too subtle to be made the subject of rigid investigation. All that can be said of this hypothesis is, that it is not *necessarily true*. A number of independent chains might be hung from the abutments, and to each might be given that form which it would, if perfectly free, assume of itself when the load at some particular stage of its transit hung from that chain alone. Then it is clear that, while no connection existed among the several chains, the load acting on each in succession would not tend to distort any of them, *i. e.* would not produce transverse strains. But it does not follow that this would be the case when all the chains were bound up together in one connected mass.

The "inverted arch bridge" does not seem to be an advantageous compromise between the principle of the girder and the suspension chain. An intermediate condition misses the advantages of both those structures: for if the inverted arch be only partially rigid it is subject to needless and prejudicial transverse strains;—if it be as rigid as a girder, why unnecessarily increase its length by curving it? The idea of our correspondent that the curvature obviates its tendency to deflect by its own weight, seems to us unfounded; for however much the structure was bent when first put up, it would tend to bend still more when its ends merely rested upon the abutments. We cannot positively undertake to assert that the *suspension of a curved beam* has no peculiar advantages; but they have not yet been pointed out, and we are unable to discern them.—EDITOR.

ELECTRIC TELEGRAPHS.

It is extraordinary that we should have had to wait so long for the introduction of a system of electric telegraphs, seeing that a century ago it was known that the electric fluid could be sent through a coil of wire two miles long, as was done in the experiments at Hampstead, while a coil had also been carried across the Thames. Papin, too, in the beginning of the last century, had sought a means of communicating power and motion to a distance. Had, however, such a means of communication as that by the electric telegraph been adopted, it would have languished in the then state of the roads, and the then state of society, for it would not have answered commercially, and its failure might have been most prejudicial. It has been reserved for our day to apply this invention, and to give one to the many characteristics which make it an era of progress. Beside the locomotive, the steamship, and the daguerreotype, the electric telegraph may take its place; and the day is perhaps not very distant, when our furthest islands will by the telegraph be brought under our immediate rule.

Having been among the first in the field, and having by the Slough line proved the practicability of the system, we have allowed the Americans to get in advance of us, for they had in 1846 sixteen hundred miles in practical commercial working, while we can hardly be said, even at present, to have any great extent of telegraph in use, although we have a great length laid down. Next year will redeem us from this charge, for we shall have two thousand five hundred miles, but it will not exculpate the government for having so long neglected this admirable invention. It is some comfort that we are ahead of France and all the European kingdoms. In the want of machinery for extending electric telegraphs we have to regret the neglect of the government in withholding the introduction of railways in India, where the telegraph would be invaluable in governing territories so vast, and where the number of English functionaries is unhappily limited.

We have now arrived at an era in the telegraph, for at the date of this publication, the metropolis has been brought into immediate communication with Liverpool, Manchester, and many of the great centres of trade and manufactures. The Electric Telegraph Company have brought their operations to that stage that they can convey intelligence to sixty great towns, and this seems an appropriate time for laying some account of their proceedings before the public, the more so as the full effect of this admirable invention does not seem to be so well appreciated as it might be in comparison with its vast capabilities, and the influence which it will exercise upon every class of the community, both morally and physically.

The operations may be considered as having begun with Mr. Cooke and Professor Wheatstone, who, after labouring singly for some time, in 1837 took out their first patent. It is understood that Professor Wheatstone applied himself more to the purer philosophical experiments, and that Mr. Cooke has taken charge of the practical detail, and at last brought the invention to its present bearing. We say nothing of other parties who have laboured on this subject, for our business is now with the Electric Telegraph Company. Soon after Messrs. Cooke and Wheatstone took out their patent, they laid down a line nineteen miles long on the Great Western railway, between London and Slough, the working of which was most successful, although of course it did not satisfy those who thought the system might fail if extended to Liverpool or York. It took many years to urge the system forward, and it was not till 1846 that a company was incorporated, called the Electric Telegraph Company, for carrying it out on a large scale. Contracts had however been made, and works carried on, so that before the act of incorporation the company was already in activity, and had by the end of 1846 laid down 1000 miles of telegraph. At the same date Professor Morse, in America, had laid down 1600 miles.

The system has been chiefly carried out in connection with railways, because the value of the telegraph to the railway companies has induced the latter to adopt it, and to make advantageous arrangements for laying it down. The years 1846 and 1847 have therefore been chiefly employed in laying down the wires, and their working on a large scale has been retarded until now by the non-completion of the wire between London and Rugby, on the North Western railway. On the 13th November this link was completed, and the London prices were at once conveyed to Manchester. The new metropolitan station has likewise been partially opened, and by the new year the whole plan will be in full operation. During the present year the metropolitan station has been in the Strand, and the working has been chiefly for government purposes along the South Western line to Gosport, although latterly much general business has been transacted. The organization of a new system has called for the exercise of much labour and ingenuity in the engineering and the signals departments, the principal officers of which are Mr. Hatcher, recently of King's College, and Mr. Whishaw, author of the "Railways of Great Britain," and the inventor of the hydraulic telegraph. In the standard work on the "Railways of Great Britain," Mr. Whishaw proposed uniformity of railway time, and a mode of communication between guard and driver, which with many other practical suggestions are now carried out. At a given time every morning a signal will be made from the central station, and the needle will be brought to the vertical indicating Greenwich mean time, by which all the telegraph clocks will be set. As this arrangement, most important to travellers, will now be carried out over the country, we may observe that local clocks and watches can be made with a double minute-hand, so as to show local time and mean time. Although much controversy has been raised about mean time, and many eminent men have opposed it, it has received the sanction of the astronomer-royal, who has proposed the adoption of it for the great clock at the palace of Westminster, which is to be set by electric telegraph from Greenwich. The system of codes adopted by the Electric Telegraph Company, has been, we believe, entirely constructed and arranged by the same gentleman. On account of the extent of the operations of the company a great many mechanics have been employed in making the various apparatus and in laying down the wires, and many works of great nicety in their execution have been carried out.

The company is not restricted to Messrs. Cooke and Wheatstone's patents, but has power to avail itself of all inventions in which electric power is used. They have therefore purchased many patents and inventions, among the chief of which may be mentioned Bain's electrical clock, an invention, the full value of which is far from being known. At the offices in the Strand is a model-room, which contains a large collection of telegraphs of various construction, and of clocks. This model-room does great credit to the company, and is a museum of great value to the practical man. It will be recollected that at Sir John Rennie's conversaziones in the spring, among the many novelties which the learned president brought before his guests, was a collection of telegraph apparatus. This was contributed by the Electric Telegraph Company, and formed not the least interesting contribution to the temporary museum in Whitehall Place.

In the model-room in the Strand, the collection in which will, we presume, be removed to the city, there is every thing necessary to illustrate the subject, though of course it does not contain every telegraphic invention. Several apparatus show the improvements which have been gradually made in the needle instrument, so as to make it capable of working. Two ingenious telegraphs communicate by sound. One of these, the invention of Professor Wheatstone, strikes two bells of dissimilar sound, the combination of the two producing the letters, as in the double needle telegraph. Another, the discovery of a workman, gives a humming noise from a wire. The effect is singular, and was a chance discovery. At present it is of no moment, but the preservation of a model by the company serves to encourage the spirit of discovery, while what is now merely trivial may become the germ of a valuable application. It is deserving of note that already the officers and workmen employed on telegraphs have been the means of making many useful suggestions, and we may anticipate the best results from an energetic body of employees, if the company are liberal. Notwithstanding all that has been said about railway improvements, it is well known to practical men that very great improvements have been effected by railway officers, and that a large amount of talent is constantly and energetically directed to the perfection of the system. The names of George and Robert Stephenson, Brunel, Braithwaite, Booth, Gooch, Gray, Edmonson, are only a few as a specimen of those who have contributed to the practical improvement of railways. In a few years the Electric Telegraph officers will, we hope, have given equal proofs of zeal and ingenuity.

The printing telegraphs in the model-room are illustrated by several apparatus of various forms, some for printing by letters, and others by signs. The company make use at their stations of the needle telegraph, but as the working of this is doubtful, and other telegraphs move quicker, it is quite open to them to change their instruments, as they have the wires laid down, and the wires are used under whatever system. While adverting to printing telegraphs, which print their message in black, we may observe that it is perfectly competent to make a telegraph which shall use different colours, and indeed a mode of shading was long ago suggested by Mr. Hyde Clarke.

The business of the company in electric clocks will no doubt be

very large in the end, as they admit of such useful application in public and private establishments. In the course of a short time no public office will be without a clock dial in every department, and when the example has been set wide enough there will be few private houses without a dial in every room. It is a small thing, but it is no mean thing to increase habits of punctuality in a population. Those who have noticed in foreign countries the disregard of the value of time among unenterprising populations, know the worth of our greater luxury in time-pieces. The Electric Telegraph Company, however, will be satisfied with the pecuniary result, without seeking further as to the public benefit they may effect. The price of a clock is at present of course rather high, namely, sixteen guineas, and of companion clocks, ten guineas each. A great objection to electric clocks at present is, that depending on the electric currents of the earth or on a battery, their regularity cannot be depended upon.

The metropolitan station, designed by Mr. Hunt, is very well situated. It occupies what was lately Founders' Hall and the adjacent premises, having entrances in Lothbury from Founders' Hall-court, and in Moorgate-street. The doorway in Founders' Hall-court is handsomely carved in stone, and though small makes a good façade. The central hall or counting house is one of the handsomest works lately executed. This station is within a few minutes' walk of the Bank, Stock Exchange, Royal Exchange, Lloyd's, the joint stock and private banks, assurance offices, in the heart of business, and not far from the Corn Exchange, Commercial Rooms, Coal Exchange, and the seat of the Manchester warehouses and colonial produce warehouses. The newspaper offices are further removed, but in the end means will be found of accommodating this class. The government offices, houses of parliament, courts of law, and places of west-end business are also at a distance, but the city is the district which will pay best, and it is impossible to provide for all at once. So far as the city office is concerned, the judgment of the managers has been well shown in its selection.

The principle of Cooke and Wheatstone's telegraph is founded on the discovery of Professor Œrsted in 1819, that a magnetised needle has a tendency to place itself at right angles to a wire along which a current of electricity is passing. By the movements of such a needle on a dial an alphabet is formed, which serves as the means of communicating messages.

In the other forms of telegraph a disc is made to rotate, bearing on it letters or signs, and this is effected in virtue of the property soft iron has of becoming temporarily magnetised by an electric current being passed along a wire coiled in a spiral around it. The same principle is adopted in all the apparatus for ringing the alarum in order to give notice that the telegraph is in action. It is to be observed that the telegraphs in the United States, France, and Prussia, are on the disc system; in Baden Highton's telegraph has been used. Most of the telegraphs in England are needle telegraphs, that on the South Devon is a disc telegraph, and that in the Box Tunnel on Nott and Gamble's plan.

The disc telegraphs are worked either by the voltaic battery or the magneto-electric machine, power being derived from a permanent magnet. With these telegraphs, two wires only are necessary, one for the telegraph and one for the alarum; but the needle telegraphs, for commercial purposes, require three wires, two needle-wires for the telegraph and one wire for the alarum.

As now laid by the Electric Telegraph Company, on their best system, two wires are employed for each principal station, the wires used being of iron, of No. 8 gage, and one-sixth of an inch diameter. These are galvanised, and come very cheap. The weight is about 38lb. to the hundred yards, or 480lb. per mile. The wire is welded together in lengths of about a quarter of a mile each. These wires are fixed to standards, at distances varying from 45 to 55 yards apart, and at each quarter of a mile is a stronger standard, where a connection is made. The wires are kept taut by a simple arrangement, which it is unnecessary to describe. In consequence of this mode of suspending the wires on standards, which was first adopted in 1842, a great economy is effected, and the system admits of a more extensive application, as now it may be laid anywhere wherever the standards can be put up; and as the population get accustomed to this invention, it can be put up as safely in the streets, or in the roads, as gas-lamps are now left; though of course it is premature to anticipate such advancement at present. Under Brett and Little's system it can, we believe, be laid much cheaper than now.

The original method of laying the wires was to cover them with silk or cotton thread, and then with pitch, resin, caoutchouc, or some other non-conducting substance, enclosed in earthenware tubes, in wood trunks, or in iron pipes. At that time, there were several inventions for laying the telegraph wires in asphalt. The great expense of the system was one of the obstructions to its extension at an earlier period. Our readers will recollect that pipes were used on the Great Western and Blackwall Railways. One purpose in the pipes was to prevent any interference with the telegraph wires; but this precaution is now considered unnecessary. The connecting wires between Nine Elms and the Strand stations, and between Euston-square and the metropolitan stations, are laid in pipes (Mr. Freeman Roe being the contractor); but, as we have already observed, they will in the end be, in most cases, laid on standards in the streets. At the present moment, our main streets are filled with cast-iron pipes for gas, for water, and for electric telegraphs. Liquid manure is also to be laid on, and we believe Professor Wheatstone contemplated a sound telegraph, which should play music. The professor contemplated the conduction of sound; but waiting till that is accomplished, it is quite easy to play music at a distance by the present resources of science. With a sufficient number of wires, a grand piano might be played in London and Liverpool at the same time; and nothing would be easier than for one organst to play in two cathedrals, or to play a set of chimes in St. Paul's and in York Minster simultaneously. Professor Wheatstone's bell telegraph, in the model-room of the Electric Telegraph Company, gives the elements of such an apparatus. In Flanders, every town has its set of *carillons* or chimes, playing elaborate tunes, and having its carilloneur, who plays on Sundays. In time, the whole of these may be worked together, or perhaps the towns of England supplied with the luxury of *carillons*. Professor Wheatstone, however, proposes to go beyond this, and to convey musical sounds to a distance.

A great economy has already been effected in the number of wires used. In the earliest Slough instrument, five needles were used, and double wires for each. The application of the principle that the earth could be made to serve as half of the circuit, and its adoption by Mr. Cooke in his patent of 1842, at once abolished half the wires, and by successive improvements, the number of needles was brought down to four, to three, and to two, and, for some purposes, even one. Thus, where twelve wires were necessary in 1842 for one station, two are now sufficient, while the cost is decreased in a very much greater ratio by the wires being galvanised instead of wound in cotton or silk, and by their being suspended in the air instead of being laid in pipes. Perhaps, in the end, a lighter wire will be used, and the system will be indefinitely extended. It is impossible to consider the system as being otherwise than in its earliest infancy, and we may expect, as in railways, to see very great modifications. The locomotive, after being increased in size to the magnitude of the "Great Western," is now likely to be brought down to the proportions of a steam-carriage. Nothing is so dangerous in new inventions as to prejudge.

The instruments used are Cooke and Wheatstone's, and are either single or double needle instruments. The latter is preferred. They are both on the same principle, except that the latter is double the former. As seen from the outside, the double needle telegraph shows two needles suspended like clock-hands on a dial. Each of these needles is the duplicate of another within the instrument, and behind the dial, and which latter is the real needle. This needle is suspended in a light hollow frame of wood or metal, round which are wound two sets of fine copper wire, coated or insulated with silk or cotton. About 200 yards of wire, $\frac{1}{180}$th of an inch diameter, is used for these purposes. This coil is connected with an electro-galvanic battery. A great difficulty of the needle telegraph is to stop the oscillations or vibrations of the needle when set in motion. This is attempted by giving a greater extension and weight to the lower limb of the needle.

On the instrument, below the dial, is a handle, which is so formed as to turn on or break off the connection of the battery with the conducting wires, and so to transmit motion to the needle, which, according to the way in which the current is passed, may be deflected to the right or left.

In the double-needle instrument, the alphabet is formed by the production or repetition of three combinations. The needles being placed parallel, the right-hand needle may be worked or the left-hand needle, the two together, or the two alternately; accordingly as this is done once, twice, thrice, or four times, a large number of alphabetical or other characters is obtained. The double needle has this additional economy over the single needle, that in many combinations the two handles are worked together; in other telegraphs of a simpler construction the saving would be still greater.

The needle being itself a magnet, is subject to disturbance from the free electricity of the atmosphere in particular states of weather, so that its working is very uncertain; and although some modifications and improvements are made, this does not obviate

the objections. To prevent the needle from traversing too far, it is confined by pins on either side. On a recent occasion all the telegraphs throughout England were deflected for so long a period that business was wholly stopped.

It is to be noticed, that the communication is carried through the instrument, which is a part of the chain of connection. At each station used, must be an instrument; but where the correspondence is small, several instruments may be used with the same wires; but of course two stations cannot be worked together,—one only can use the telegraph at a time. Where there is larger correspondence, separate wires and instruments are used for each station. An objection at present is that one instrument being disordered, which is not unfrequently the case, the whole set suffer.

Where several instruments are put on one set of wires, there is an advantage in sending a simultaneous message. Thus, in the case of the Queen's speech and proroguing Parliament next year, it may be simultaneously communicated to sixty stations by one clerk in Lothbury; and we may conceive the period when a public functionary may simultaneously convey instantaneous instructions to a thousand subordinates, thus surpassing all that the printing-press has ever yet accomplished. Already, the superintendents of railways, seated in their London offices, can give general instructions every morning to their station-masters attending in the telegraph-rooms. For most of the purposes of the subscribers'-rooms, the whole system of telegraphs put in communication will allow of one message or list of prices or quotations being used for all, which is a great economy. Thus the price of shares at Manchester, of cotton at Liverpool, of sugar in Mincing-lane, or of corn at Wakefield, will be simultaneously announced all over the country.

The bell, or alarum, may be considered at present an essential part of the telegraph system. By setting the alarum in action, notice is given to the telegraph clerk that a message is going to be sent. We question, however, whether the bell will in the future be necessary at large telegraph stations, where clerks are on duty day and night, and the instruments, perhaps, in constant use. At present, the alarum may be set in action from the telegraph wire, or a separate wire may be used. The defect of the former plan is, that if the clerk, on finishing his message, does not leave his alarum in the circuit, the alarum cannot be set in action, and the only way to attract his attention is the chance of his seeing the needles working. As this contingeney virtually neutralizes the use of the alarum, it is considered preferable to have a separate bell for the alarum. The alarum is a piece of clock-work, to be set in action by the connection or disconnection of two pieces of soft iron, formed into a horse-shoe magnet, and covered with a coil of fine copper wire insulated with silk or cotton. When this horse-shoe is magnetised, it attracts an armature of soft iron, which moves on an arbor, and lets loose a catch, which sets the clock-work in motion. Formerly, the magnet was made to act directly on the hammer of the bell. Lately, great improvements have been made in alarums by other inventors.

The single needle telegraph is sometimes used for railway purposes, where a limited number of signals is required; but for all others, the double needle is used, and the difference in price is not sufficient to justify the use of a less effective instrument. As, however, in the case of the double needle instrument, accident may happen to one of the wires, the clerks are taught the use of the single needle signals, so that communications may still be carried on. This is the more necessary from the liability to disorder. We may observe, that in case of injury to a particular line of wires, as that on the old Manchester and Birmingham Railway for instance, the communication with Manchester could still be carried on by forming a circuit with Sheffield, Leeds, Liverpool, or any other of the places remaining in connection with it and the metropolis. Unless all the wires round a town be disturbed, the communication cannot be stopped, so readily can a line of correspondence be formed; and it is at present considered of little importance to send a message round by any distance, as no perceptible difference in speed or efficiency is found between a direct or a circuitous route in the transmission of electric messages. Hitherto, all correspondence with Manchester has been sent circuitously by Rugby, and over the Midland Railway. In a political, and even in a commercial point of view, this fact is of some importance, as it guarantees the stability of this mode of communication. It is to be noted, however, that the Electric Telegraph Company have hitherto worked their messages by relays, and this is the case on the South Eastern, which argues some defects. The company's telegraph is a failure on the South Devon line, and in the Summit Tunnel on the Sheffield and Manchester railway. Nott and Gamble's telegraph has also failed in the Box-Tunnel.

The mode of transmitting messages by telegraph has already been subjected to revolutions. When the idea was put forward of spelling words, of course it was suggested that combinations might be formed of signals standing for words. This was not, however, then found to work well, and the competent author of the article on electric telegraphs, writing in "Weale's Pocket Book," in the end of the year 1846, says—"This method has been fully tried, and has been relinquished only upon a conviction of the greater certainty and eventual quickness of the literal communication." At the present moment, the company are again working by signals or words, and with great success, upon Mr. Whishaw's system. It will strike every one who has given his attention to the subject, that each subject relating to shipping, to the stock exchange, to produce markets—will have its own technical language, in the cognate business of short-hand writing, called "arbitraries," and for which signs may be used as they are in short-hand. The merit of Mr. Whishaw's system consists in its special application, while the failure of the previous attempts was in their generalization. All successful codes of signals, or telegraph communications, have been special; and the same may be said of short-hand arbitraries. A law short-hand-writer will find constantly recurring—"plaintiff, defendant, affidavits, plea," and a number of other terms, which it would be a work of supererogation to write in full; and so in each department; but this has been left to systematization by the individual rather than made a work of science. Sea signals have been rendered very simple by their application to nautical purposes, though the attempts to apply them to more extended communications have failed.

In Mr. Whishaw's system for the Electric Telegraph Company, a code of signals is applied to each class of communications. Thus there is a code for shipping intelligence, a code for racing, a code for share lists, a code for corn-market prices, and so forth. On the message being commenced, a signal is made what code is used, so that the clerk who receives the message is prepared for the nature of the signals. As the number of signals which can be made in a given time is limited, it is evidently of great importance to economise time by the adoption of arbitraries, instead of spelling every word, letter for letter. Indeed, if an expedient of this kind were not adopted, it would be impossible to carry on the correspondence between the great towns. As it is, it may be reasonably expected that business will so far increase on the organization of the system, as to require the adoption of more than one line of telegraphs between the metropolis and such towns as Manchester and Glasgow. We may note here, that it will be curious to observe whether the number of telegraph messages will bear any correspondence with the number of post letters sent to each town. There can be no doubt, however, that to give accommodation to the public new companies will be formed, as in other branches of enterprise.

On a message being delivered in writing at the telegraph office, it is "translated" into telegraph language, transmitted by a telegraph clerk, received by a telegraph clerk at the other end, re-translated there, and written out and given to a messenger for delivery. Each message is accompanied by preliminary signals, to call the attention of the clerk to be addressed, and to signify to him the nature of the message, and the code to be used. It may readily be conceived that it is of great assistance to the clerk to know the class of message he is going to receive, as he is thereby better prepared to understand its import. It is like a reporter in the gallery of the House of Commons understanding the speaker whom he is following, and which enables him more fully to catch and express his meaning, than if the subject were unfamiliar to him. In time, no doubt, the telegraph clerks will divide among themselves the labour of transmitting the several classes of intelligence, and this will have a tendency to ensure greater accuracy and rapidity. In order to obtain more accurate delivery of a message, the company offer, on the payment of an advanced price, to have it repeated, so that there may be a security for its being fully understood; and this is necessary, as errors must be expected to creep in from frequent imperfection in the instruments, from unintentional error on the part of the sender, and from misinterpretation on the part of the receiver. These kinds of messages will be peculiarly open to those "equivoques," now known as "errors of the press," in printing, where the insertion of one wrong letter alters the whole meaning of a word or sentence. We may be prepared, therefore, for letters addressed to the great censor of the age, headed, "Shameful Mis-

management of the Electric Telegraph Company," "Shameful Oppression," "Shameful Negligence," "Shameful Monopoly," and so forth, in which the real or fictitious correspondents declare the dreadful sufferings to which they have been exposed by the errors and delays of the telegraph clerks—how "owls" were ordered for dinner, instead of "fowls,"—"pigeon" for "widgeon," "veal" for "teal," "cats" for "skates," "swipes" for "snipes," and many sundry grievances, which could not be complained about hitherto, as there were no telegraph offices to be belaboured by the querulous, dissatisfied, and inconsiderate. The telegraph grievance will be a great safety-valve to the railways, for the former will so occupy the *Times* and *Punch*, as to leave no room for the last case of neglect by Mr. Hudson, or the last instance of being five minutes behind time on the Eastern Counties. When telegraphs come to be abused as well as railways, it will be a sign that they have done some service, and have merited well of the public.

The lowest charge for the delivery of a message at present is half-a-crown, for which thirty words are sent thirty miles—though it is to be hoped for the public accommodation that the prices will be reduced. The charge increases, of course, in the double ratio of the number of words and number of miles. In many cases, the charge will not be greatly above that which was made a few years ago for general post letters for mercantile purposes; and, indeed, merchants will have been relieved from the charge of postage, to give them a revenue for telegraph purposes. If there are any who doubt that the mercantile classes will be ready to avail themselves of the telegraph, they should be put in mind of the large sums formerly disbursed for postage, and, indeed, of the large sums still disbursed for Indian and foreign postage.

The Electric Telegraph Company, as a matter of necessity, give notice, that they do not hold themselves responsible for the speed with which the messages are transmitted, nor for delay caused by the state of the weather or apparatus. At present, the state of the weather often affects the rate of working of the machines, and sometimes to a serious extent.

The rate at which messages can be transmitted is rather lower than might be anticipated, and this arises from using the needle telegraph. It is found that about six words a minute is as much as can be practically telegraphed at present, the words being spelled literally. The last Queen's Speech was sent seven words a-minute. By using the codes, longer messages can of course be sent. The number of words which can be written by short-hand in a minute is seventy; the number of words which can be read rapidly in one minute is 280. The number of characters passed by Professor Morse is 117 as a maximum, 99 as an average. We may be prepared for the much greater rapidity of the electric telegraph in other hands. Mr. Bain promises, in the course of time, 1,000 characters: but the present rate of speed is ample for all present purposes, though we have that faith in the extension of telegraph business, that we believe it must be shortly increased. By using well-trained clerks at the chief stations, and by frequently relieving them, the utmost use will be made of the telegraphs; and they are likely to be worked night and day. For many classes of correspondence, all the words must be spelled, and no arbitraries or codes can be used; but still a large mass of correspondence will admit of profitable abridgment. Professor Morse, and many telegraphers, undertake to do a much greater number of words than those assigned by us as the present rate in England; but what one individual can do in an isolated case, is very different from the working of a miscellaneous correspondence, through a public office.

That the undertaking will turn out productive, we have no manner of doubt, because, in many cases, the company have not the property of the lines, which belong to the railways, but work them at a toll, while the revenue to be received must be very great. A line between two principal stations will yield five thousand a-year; and as the outgoings are chiefly in clerks, it will be seen that there must be a large surplus to pay the wear and tear of instruments, the cost of management and superintendence; and after yielding a toll to the railway companies, afford a very handsome return to the Electric Telegraph Company for all the capital they may be called upon to employ. They enjoy, too, the advantage of a ready-money business. A thousand a-year would, however, yield a dividend. At present the company have not wires enough for the public business, and great complaints are made of the delay.

The length of line laid down by the Electric Telegraph Company, or in progress, is now, we believe, about 2,000 miles; and the following is a list of telegraphs, with the date when laid down, and the length of line, though the materials from which we have compiled it are imperfect. It will, however, in some degree, serve to show the progress of the system:—

			Miles
1839	Great Western ...	... London to Slough	19
1842	Blackwall	...	5
1844	Yarmouth and Norwich	...	20
1845	South-Western ...	... London to Southampton	99
,,	Eastern Counties ...	... Colchester line	51
,,	,, ...	... Cambridge do.	88
,,	,, ...	... Hertford branch do.	7
,,	,, ...	... Ely and Peterborough	29
,,	,, ...	... Thames Junction	3
,,	South-Eastern	... London to Dover	88
,,	,, ...	... Ramsgate line	30
,,	,, ...	... Margate do.	4
,,	,, ...	... Maidstone do.	10
1846	,, ...	... Tunbridge and Tunbridge Wells	6
,,	,, ...	... Bricklayers' Arms line	6
1847	,, ...	... Deal do.	9
1845	Norfolk Railway ...	... Norwich and Brandon	38
1847	,, ...	... Lowestoft line	10
,,	,, ...	... Dereham do.	13
1846	Midland Counties ...	... Rugby and Derby	49
,,	,, ...	... Birmingham & Derby	41
,,	,, ...	... Derby to Normanton	73
,,	,, ...	... Nottingham and Lincoln	41
,,	,, ...	... Sheffield line	5
,,	York and North-Midland ...		23
,,	,,	... York & Scarborough	43
,,	Hull and Selby ...	...	40
,,	York and Newcastle ...	...	84
,,	,, ...	... Durham line	2
,,	,, ...	... Sunderland do.	5
,,	,, ...	... Shields do.	8
,,	,, ...	... Richmond do.	9
1845	Sheffield and Manchester	... Summit Tunnel	3
1846	South Devon	...	20
1845	London, Brighton, and South Coast	London and Croydon	8
1846	Preston and Wyre ...	... Preston & Fleetwood	20
,,	Eastern Union	...	17
,,	London and North-Western...	Wolverton and Peterborough	57
1847	Midland	... Syston and Peterboro'	40
,,	Leeds and Bradford ...	...	15
,,	Manchester and Leeds ...		61
,,	York and North-Midland ...	Hull and Burlington	27
,,	Newcastle and Berwick ...		60
,,	South Devon Extension ...		27
,,	London and North-Western...	London and Rugby	82½
,,	,, ...	Rugby to Newton	111¾
,,	,, ...	Liverpool and Manchester	31½
,,	,, ...	Crewe to Chester	30¾
,,	Southampton and Dorchester...		60
,,	Midland	Bristol & Birmingham	90½
,,	Edinburgh and Glasgow ...		46

The length of line laid down previously to 1845, was not more than 45; in that year, about 500 miles; in 1846, 600 miles; and in 1847, 1,100 miles. The total done and in hand is above 2,300 miles.

The towns to which communication will be made are above sixty, including London, Manchester, Glasgow, Liverpool, Edinburgh, Leeds, Sheffield, Birmingham, Bristol, Newcastle, Hull, Wolverhampton, Wakefield, Derby, Leicester, Norwich, Nottingham, Portsmouth, Northampton, Bradford, Coventry, Dover, Canterbury, Halifax, Rochdale, Maidstone, Southampton, Gloucester, Cheltenham, Yarmouth, Cambridge, Colchester, Ipswich, York, Darlington, Margate, Stafford, Barnsley, Hertford, Ramsgate, Deal, Folkestone, Rotherham, Tunbridge, Winchester, Dorchester, Peterborough, Huntingdon, Chesterfield, Wisbeach, Lowestoff, Chelmsford, Berwick, Scarborough, Burlington, Stamford, and St. Ives. With Bristol, the communication is circuitous round by Birmingham and Gloucester, as the Great-Western, although first in the field with the Slough line, have neglected to apply the telegraph throughout, which seems to arise from dissatisfaction with the needle telegraph, for they have allowed partial applications of two other systems. Every town in the country having above one hundred thousand people, is brought into communication with the metropolis; and the only great towns still

unsupplied are Plymouth, Chatham, Preston, Exeter, Bath, Brighton, and Oxford. The number of shire towns brought into connection is near thirty; all the chief seaports and seats of manufactures, and several watering-places.

Besides the places already enumerated, many considerable towns can be served, being already placed on the line of telegraph, as Worcester, Sunderland, Stockport, Kingston, Lichfield, Tunbridge Wells, Poole, Croydon, Watford, Maldon, Droitwich, Thetford, Beverley, Braintree, Ashford, Newark, Alnwick, Dunbar, Loughborough, Crewe, Wolverton, Leighton Buzzard, Driffield, Reigate, Romford, Bishops Stortford, Thirsk, Northallerton, Market Weighton, &c. In fact, within a very short period, the company will be able to supply the prices of above a hundred market towns, if wires enough are laid down.

In the United States, New York, Philadelphia, Boston, Baltimore, Washington, Albany, Newhaven, and Hartford, have the means of intercommunication, and a line of a thousand miles long runs to Quebec.

With regard to submarine telegraphs their practicability is indisputable. The great essay will be the line between Dover and Calais, when the two great cities of western Europe will have instant parley. Already the money markets of the two sympathise, the capitalists of the two cities are bound up with each other, and it is to be hoped these ties will be drawn closer, and the peace of the two great nations be maintained. A continuous line between London and Vienna is talked off as in progress; at any rate, we shall soon have, by a telegraphic communication with Marseilles or Trieste, the means of abridging our East Indian correspondence. The value of such correspondence to the London houses engaged in East India business and expecting remittances would have been very great during the late crisis.

If the steamboat threatens us with greater hazard of invasion during any future war, the telegraph comes in good time to counteract any unfavourable influence, by giving us instant intelligence of any danger to our coasts, and allowing of immediate, and as it may be called, personal communication between the statesmen of England and France, so as to allow negociations for peace to be carried on with more rapidity than by mean of envoys.

To the Admiralty the electric telegraph offers the means of superseding the cumbrous semaphore, and of rapid intercourse with the naval stations. We consider the Admiralty greatly blameable in not having sooner availed themselves of the system, after the success of the Slough experiment. As it is, they have only a line to Gosport. There is none to Plymouth, Chatham, Sheerness, or Milford. We do not see why a submarine telegraph should not be carried out to the anchorage at Spithead, so as to allow of readier correspondence with the admiral or officers afloat. It is no testimony in favour of government management in England and France that the clumsy semaphores, useless at night and in a fog, and useable only for a fifth of the year, should have been so long persisted in; but we entertain no doubt that so soon as the electric telegraph system is fully applied for public service, the governments will become candidates for taking its control into their own hands, or for interfering with it as they have with the railways.

A submarine telegraph which will be of great use will be between England and Ireland, and nothing but the want of energy of the government prevents them from applying it in the present crisis, when it will be a means of economising money, and most probably of saving human life. Such a telegraph is properly a government experiment, and not a commercial experiment; and for that reason it is not likely to be done until it cannot be put off any longer, and when done to be badly done.

It is to be remembered that the telegraphic establishment will be a new post-office, operating almost instantaneously, and with this advantage—that instead of the whole business being restricted to one fixed time, or to two fixed times, communication will be made at the moment desired by day or night. The way in which such an establishment must operate on society must be most beneficial. All those interested in markets, whether belonging to the agricultural interest or the mercantile interest, will, in every part of the kingdom, wherever they may be, know the state of all the markets open within a few minutes of operations being effected, while they will have the means of making purchases or sales hundreds of miles off, whereby transactions will be much quickened, and a general and uniform rate of prices will be established throughout the country. The charge for subscription is only two guineas yearly, and the subscriber, wherever he may be, has admission to the subscription rooms, in which are posted the shipping lists, the share lists from the London and provincial share exchanges, the prices current, the prices of corn, live stock, and produce, and every event of public or mercantile interest. No one concerned in any business can well avoid this payment, for it will in the end become *de facto* a tax, for no one will dare to be placed under a disadvantage to his neighbour. It will be as common as to read the newspapers.

It will readily be seen that even the man of pleasure cannot escape contributing to the revenues of the telegraph company, for political intelligence and sporting intelligence will be recorded, and wherever he may wander he will always have access to information. On going into the telegragh station he will see the state of bets at Tattersall's, and regulate his own proceedings accordingly, or learn who is the winner at Epsom or Newmarket. During the late general election, had the system been in full work, intelligence would have been sent of the state of the poll from sixty boroughs and thirty places of county elections, which are now telegraph stations. A parliamentary division will be known within a few minutes all over the country, and the faction which triumphs or which falls at St. Stephen's will within a brief period be brought under the comment of thousands of its supporters or opponents. Now the divisions are telegraphed to Liverpool and Manchester, and posted in the rooms.

The sending of private messages must be most various in its influence, and the effect of time and experience only can enable its bearing to be fully appreciated. New modes of doing business will spring up, new branches of business will be created, some perhaps be superseded, but that the result will be beneficial on the whole no reasoning man can doubt. Whoever has a sick relative at a distance, in the hourly peril of death, with life quivering on a breath, in all the agony of hope and fear, will know the value of an establishment which can give him frequent and immediate intelligence of the state of one whom he holds dear. After this example it is of little moment to picture the many ways in which personal interest will seek gratification in a correspondence which extends the power of wealth and enterprise, and widens their sphere of action. A Rothschild, a Goldsmid, or a Baring, may rule by agents in London, in Paris, in Madrid, and in Lisbon at once; but henceforth their most distant affairs will be under their own guidance, and their personal influence will be made to act in cities they have never entered, and with men they have never seen. The confidential agent or the junior partner will be a zero, and the means of safely conducting an available operation will no longer be limited by the necessity of intrusting it to a subordinate. Indeed it is impossible to contemplate, without excitement, the new world which is as it were opening before us, and to which the effects of railway and steamship intercourse, great as they are, are as nothing.

To the press the electric telegraph will be a new arm of power: the money which is now spent in horses and expresses will be appropriated in a large proportion to keeping up a greater number of agents and correspondence. It may appear at first sight that the telegraph rooms by affording so much intelligence will be curtailing the sphere of the newspapers, but they will only be interfering with them in some departments to give them greater facilities in others. The Electric Telegraph Company may announce that the mail steamer has brought to Liverpool the American president's speech, and its purport, bnt the special edition of the *Times* must give its words sent up by telegraph. Country meetings of importance will be sent up by telegraph, and it is not impossible that before long such arrangements may be made as to allow of the reporter's notes being used for telegraphic transmission. The difference in the number of signs between long-hand and short-hand (discarding most of the arbitraries), is as 275 to 170, or nearly as 5 to 3; this gives a saving in favour of short-hand of two-thirds, and allows five hours' work to be done in three, for it is to be observed in telegraphic communication, the great object is to economise the time used at the telegraph. The short-hand system was tried on the South-Western and found to answer.

It seems by no means improbable that an influence will be exerted on the jurisprudence and police of the country by the telegraph system. Perhaps we ought to say that it has already done so. The arrest of Tawell, the quaker, for murder, and the arrest of so many other criminals has given a greater efficiency to the law; the respite and afterwards execution of the convict at Maidstone, show the ready means of communication with the central authorities. But though a telegraphic message may be a sufficient authority to arrest for felony, it will be necessary to provide some new process to make this establishment available in cases of misdemeanour, and in the end it is likely to be applied in civil cases, in which already it is calculated to quicken many stages of proceeding. It may hereafter not be uncommon to have a witness at Edinburgh examined by telegraph during a trial at Westminster Hall, and other evidence be sought for five hundred miles off. It may cease to be necessary to bring up a prisoner to the superior

courts on ordinary applications, when a correspondence may be made with him at any distance.

As a means of railway administration the electric telegraph has proved its efficacy, and it is impossible to conduct single lines properly without it. Already the convenience to passengers has been very great, and that to the companies cannot be undervalued. It extends the supervision of the central authorities, and allows the most effective action to take place on every emergency, whether of accident or otherwise. Lately, some half-dozen gentlemen were on business at a minor station on the Eastern Counties line, and being desirous of proceeding early to Cambridge, they made application to stop the next train, which would otherwise have passed the station. The message was passed to the superintendent at Shoreditch, leave granted, and within half an hour the gentlemen were on their way to Cambridge, where it was of great importance they should arrive early. A lesser case, which happened on the South Eastern a month or two ago, may be worth notice. An old woman proceeding from Minster to Tunbridge, or some intermediate station, after paying her second-class fare, in her hurry left her money on the counter. On arriving at Canterbury she found out her loss and wished to return to Minster, but the superintendent persuaded her to go on, in the hope that she might be able to learn something of it at Ashford. On her arrival there she was told that the money had been found on the counter at Minster to the amount she described, and at the next station the sum was handed to her; but though glad to receive the money, she could not repress her fears that the railway officers to whom she was indebted had dealings with the powers of evil. In the United States it is said that a marriage was contracted by railway between two parties hundreds of miles apart. Under the law of Scotland a telegraph marriage might, we believe, legally take place. Telegraph clerks are sometimes however able to help themselves, and a case lately occurred of a superintendent, having to convey to a branch bank notice of stoppage, drawing out his own balance before he delivered the notice.

In the progress of such an invention, and in its greater economy, its application must be very extensive. In the last session a telegraph was worked between the House of Commons and the committee rooms, and it is evident that it can be usefully employed in large offices and factories, where in time the telegraph wire will be as extended as the bellwire. The greater the extension the greater the prospect of improvement and economy to the public, and we can only wish, though we scarcely hope, that a system so valuable will be received in a favourable spirit on the part of the public, and meet with a greater degree of encouragement than is usually afforded to new inventions.

ON THE LAP AND LEAD OF THE SLIDE VALVE.

The slide valve is that part of a steam engine which causes the motion of the piston to be reciprocating. It is made to slide upon a smooth surface, called the cylinder face, in which there are three openings to as many pipes or passages: two for the admission of steam to the cylinder, above and below the piston, alternately; while the use of the third is to convey away the waste steam. The first two are, therefore, termed the induction or steam ports, and the remaining one the eduction or exhaustion port.

The slide is enclosed in a steam-tight case, called the slide-jacket; and motion is communicated to it by means of a rod working through a stuffing-box.

The steam from the boiler first enters the jacket, and thence passes into the cylinder, through either steam port, according to the position of the slide, which is so contrived that steam cannot pass from the jacket to the cylinder through both steam ports at the same time, or through the eduction port at any time.

CASE 1.—WHEN A SLIDE HAS NEITHER LEAD OR LAP.

Fig. 1 represents the cylinder face for a "Murray slide" without lap; *a* and *b* being the induction ports, and *c* the eduction.

Figs. 2, 3, and 4, are similar sections of the nosle, showing the slide in its central and two extreme positions. It occupies the mid-position, fig. 2, when the piston is at either extremity of its stroke; the extreme position, fig. 3, when the piston is at half-stroke in its descent; and that shown in fig. 4, when the piston is at half-stroke in its ascent.

When a slide has no lap, the width of its facing, at *f* and *g* (fig. 2), equals that of the steam ports; the lap being any additional width whereby those ports are overlapped.

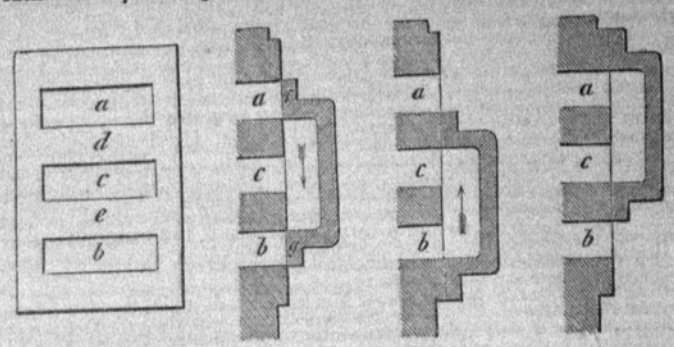


Fig. 1. Fig. 2. Fig. 3. Fig. 4.

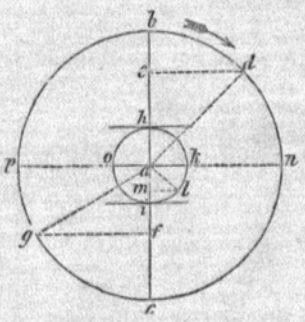
That the waste steam may have unobstructed egress, the exhaustion port *c* must be made of no less width than the steam ports; and, for the same reason, the bars *d* and *e* should correspond with the slide face at *f* and *g*. The three ports, together with the bars between and beyond them, are therefore drawn of equal width; the total length of the slide being equal to the distance between the steam sides of the steam ports.

The distance through which the slide moves, in passing from one extreme position to the other, is called its *travel*; which, in this case, equals *twice the port*.

When the motion of a slide is produced by means of an eccentric, keyed to the crank shaft and revolving with it, the relative positions of the piston and slide depend upon the relative positions of the crank and eccentric.

Demonstration.

Diagram 1.



Let *a b*, diagram 1, represent the crank; then *b* being the crank-pin, and *a* the centre of motion, the larger circle represents the orbit of the crank, and its diameter *b c* the stroke of the piston. Supposing the cylinder to be an upright one, having the crank-shaft immediately above or below it, the connection between the piston-rod and crank being merely a connecting-rod, without the intervention of a beam, it is evident that when the position of the crank is *a b*, the piston will be at the top of the cylinder, and at the bottom when its position is *a c*. The relative positions of the crank and piston, at any point of the stroke between the two extremes, depend upon the length of the connecting-rod: for the present, however, let us suppose the connecting-rod to be of infinite length, and therefore always acting upon the crank in parallel lines, so that when the crank is at *d*, *e* will be the apparent position of the piston, and *f* the same when the crank is at *g*; the piston being represented by the sine of the arc described by the crank from either of the points *b* and *c*, in the direction of the arrow.

The diameter *h i*, of the inner circle of the diagram, represents the travel of the slide, and its radius the eccentricity of the eccentric; or, regarding the eccentric as a crank, the radius may be said to represent that crank, as *a b* represents the main crank. The travel of a slide, without lap, being equal to twice the port, the two steam ports are represented by the spaces *a h* and *a i*, but transposed, *a i* being the passage to the top of the cylinder, and *a h* that to the bottom.

Supposing the piston to be at *b* (the top of the cylinder), the position of the slide will be that shown in fig. 2, the direction of its motion being downward, so that the port *a* (same figure), or *a i* in the diagram, may be gradually opened for the admission of steam above the piston, until the piston has arrived at half-stroke, when it will be fully open, as shown in fig. 3. The direction of the slide's motion is then reversed, so that when the piston has completed its descent, the port *b*, figs. 1 to 4, or *a h* in the diagram, will begin to open for the admission of steam beneath it, and exhaustion will commence from above it through the port *a*, or *a i*, and exhaustion port *c*, the slide being again brought into its central position, fig. 2.

Now the slide being at half-stroke, when the piston is at either extremity of its stroke, if we make *a b* the position of the crank, *a k* will be that of the eccentric; and the axis of the crank being

likewise that of the eccentric, they must necessarily revolve in equal times, and always at the same distance apart; therefore, when the crank has reached the point *d* (supposing it to move in the direction of the arrow) the eccentric will have advanced to *l*, and *e d* and *l m* represent the positions of the piston and slide respectively; showing, that when the piston has descended to *e*, the steam port *a i* in the diagram, or *a* figs. 1 to 4, will be open to the extent *a m*. Again,—when the crank is at *n*, and the piston consequently at half-stroke, *a i* will be the position of the eccentric, the port *a i* being fully open, and the slide occupying the extreme position shown in fig. 3. The direction of the slide's motion is now reversed, and the port is again gradually covered by the slide face until the positions of the crank and eccentric are *a c* and *a o*, when the piston will have completed its descent, and the port *a i* will be completely closed, the slide being again brought into its central position, fig. 2. The opposite steam port *a h* now begins to open for the admission of steam, and the direction of the piston's motion is reversed; the port continues to open until the crank and eccentric reach the points *p* and *h*, when the piston will again be at half-stroke, and the slide in its extreme position, fig. 4. Meanwhile, exhaustion from above the piston has been taking place, to the same extent, through the port *a i*. Finally,—the piston having completed its ascent, the slide again occupies its original position, fig. 2, and, its course being downward, steam is again admitted into the cylinder, through the port *a*; the piston then begins to descend, and, at the same instant, exhaustion ceases from above, and commences from below it, through the port *b*.

It is sometimes urged against the use of the eccentric, as a means of actuating the slide, that the steam ports are opened and closed too slowly; but it must be remembered that the piston does not move at a uniform velocity, as the crank does; for example, while the crank describes the arc *b d*, the piston descends only from *b* to *e*, the versed sine of that arc; and its velocity is gradually increaed as it approaches the middle of its stroke, where it is greatest, being equal to that of the crank. Again,—as the piston approaches the end of its stroke, its velocity is diminished in the same ratio as that in which it had previously increased, until the completion of its stroke, where it remains stationary during the small space of time in which the direction of its motion is reversed.

Now, it must be obvious that less steam is required to impel the piston at a slow rate than at a rapid one; and a glance at diagram 1 shows that the steam admitted into the cylinder, when the slide is actuated by an eccentric, is at all times proportioned to the velocity of the piston, the port being least open when the piston is near the end of its stroke, and fully open when it is at half-stroke.

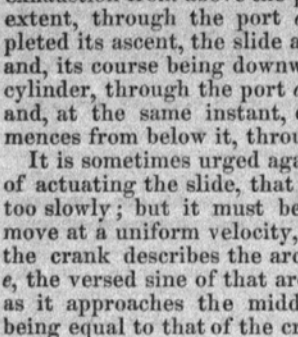
When an eccentric, instead of being set, as in the preceding case, so that the steam port shall only begin to open when the piston commences its stroke, is so placed that the port shall be open to some extent prior to the commencement of the stroke, the width of that opening is termed

The Lead.

The non-use of lead is disadvantageous, chiefly because at the commencement of every stroke, the steam has to contend with the whole force of that which had impelled the piston during its previous stroke. But, besides obviating that disadvantage, the lead is of essential service in locomotive engines, "where it is found necessary to let the steam on to the opposite side of the piston before the end of its stroke, in order to bring it up gradually to a stop, and diminish the violent jerk that is caused by its motion being changed so very rapidly as five times in a second. The steam let into the end of a cylinder before the piston arrives at it, acts as a spring cushion to assist in changing its motion; and if it were not applied, the piston could not be kept tight upon the piston-rod."—*Description of Stephenson's Locomotive Engine*, "*Tredgold*."

Case 2.—When a Slide has Lead without Lap.

Diagram 2.



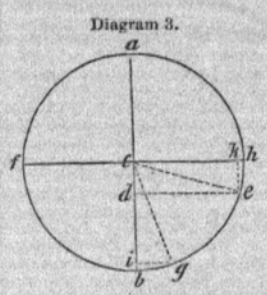
Let *a b*, diagram 2, represent the stroke of the piston; *c d* the travel of the slide; and *e f* the *lead*; then, supposing the piston to be at the top of the cylinder, *e a* is the position of the crank, and *e g* that of the eccentric. Following the course of the crank, in the direction of the arrow, we find the port *c d* fully open, not, as in the former case, when the piston is at half-stroke, but when it has descended to the point *h*,—the arc *a i*, described by the crank, being equal to the arc *g d*, described by the eccentric. Again,—we find the port re-closed when the piston has descended to *i*, at which point exhaustion commences from above the piston through *e d*, and steam enters below it through *e c*, for the return stroke, at the commencement of which the port *e c* is open to the extent *e l* (equal to *e f*) for the admission of steam, while *e d* is open to the same extent for exhaustion.

It is to be remarked, that the amount of *lead* is necessarily very limited in practice, its tendency being to arrest the progress of the piston before the completion of its stroke. The greatest possible amount of lead equals half the travel of the slide. The eccentric would in that case be set diametrically opposite to its first position, which would have the effect of reversing the direction of the piston's motion.

In the case of a slide having lead without lap, the distance of a piston from the end of its stroke, when the lead produces its effect, is proportional to the lead as the versed sine of an arc is to its sine, supposing the radii of the crank and eccentric to be equal.

Demonstration.

Diagram 3.



Let *a b*, diagram 3, represent both the travel of the slide and the piston's stroke; then *c a* and *c b* represent the steam ports. And let *c d* represent the lead; then *c a* and *c e* represent the crank and eccentric, the piston being at the top of the cylinder. Now, steam will enter the cylinder, below the piston, when the eccentric is at *f*, and the crank at *g*; for the arcs *a e g*, and *e b f* are equal. Again,—the arc *g b* is equal to *h e*; therefore, *i g* is equal to *k e*, and *i b* to *k h*. Now, *k e* is the sine of the arc *h e*, and *k h* (equal to *i b*) is its versed sine: hence

Rule I.—*To find the distance of the piston from the end of its stroke, when the lead produces its effect:*—

Divide the lead by the width of the steam port, both in inches, and call the quotient sine; multiply its corresponding versed sine, found in the table, by half the stroke, and the product will be the distance of the piston from the end of its stroke, when steam is admitted for the return stroke, and exhaustion commences. Or,

Rule II.—*To find the lead, the distance of the piston from the end of its stroke being given:*—

Divide the distance in inches by half the stroke in inches, and call the quotient versed sine; multiply its corresponding sine by the width of steam port, and the product will be the lead.

Example 1.—The stroke of a piston is 48 inches; width of steam port $2\frac{1}{2}$ inches; and lead $\frac{1}{2}$ inch: required the distance of the piston from the end of its stroke, when exhaustion commences.

Here, ·5 ÷ 2·5 = ·2 = sine; and versed sine of sine ·2 = ·0202.

Then, ·0202 × 24 = ·4848 inches.

Example 2.—The stroke of a piston is 48 inches; width of steam port 2·5 inches; and distance of piston from the end of its stroke, when exhaustion commences, ·4848 inches: required the lead.

Here, ·4848 ÷ 24 = ·0202 = versed sine;

and sine of versed sine ·0202 = ·2.

Then, ·2 × 2·5 = ·5 = lead.

When the lead of a slide is equal to the width of steam port multiplied by any number in the first column of the following table, the distance of the piston from the end of its stroke, when steam is admitted on the exhaust-side, will be equal to half the stroke multiplied by the corresponding number of the second column. Or, if the distance of the piston from the end of its stroke, when steam is admitted on the exhaust-side, be equal to half the stroke multiplied by any number in the second column, the width of steam port multiplied by the corresponding number of the first column equals the lead.

When the lead is equal to the width of steam port multiplied by	The distance of the piston from the end of its stroke, when steam is admitted on the exhaust-side, equals half the stroke multiplied by
·0625	·0019
·09375	·0044
·125	·0078
·1875	·0176
·21875	·0242
25	·0317
·28125	·0403
·3125	·0501
·34375	·0609
·375	·0730
·40625	·0862
·4375	·1008
·46875	·1166
·5	·1339

THE LAP.

A slide is said to have *lap* when the width of its face is greater than that of the steam ports, the ports being thereby overlapped, as in fig. 7.

It is to be remarked that slides should have some degree of lap on both the steam and exhaustion sides of the passage, because, although in theory an aperture may be said to be completely closed when covered by a bar of similar width, yet, in the construction of a slide without lap, we cannot insure such accuracy of *fit* as to preclude the possibility of steam entering or leaving both steam ports at the same time.

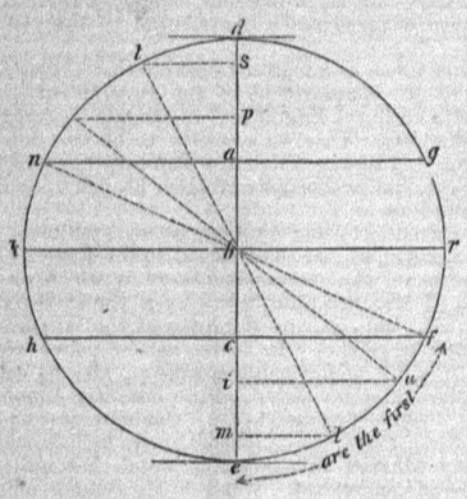
Lap on the steam side has the effect of cutting off the steam from the cylinder, by closing the port before the completion of the stroke, the remainder of the stroke being effected by the expansion of the steam already admitted.

Demonstration.

CASE 3.—WHEN A SLIDE HAS LAP ON THE STEAM SIDE, WITHOUT LEAD.

Let *a b* and *b c*, diagram 4, represent the lap at both ends of the slide; and let *a d* and *c e* represent the two steam ports; then *d e* will represent the travel of the slide, which, in this case, equals twice the steam port, plus twice the lap.

Diagram 4.



Supposing *d e* also to represent the stroke of the piston, and that the piston is on the top stroke, then *b d* and *b f* are the respective positions of the crank and eccentric; for the slide, instead of occupying its central position, when the piston is at the end of its stroke (as in Case 1), must be set in advance of that position to the extent of the lap, that steam may enter the cylinder when the piston begins to move. (See fig. 5.)

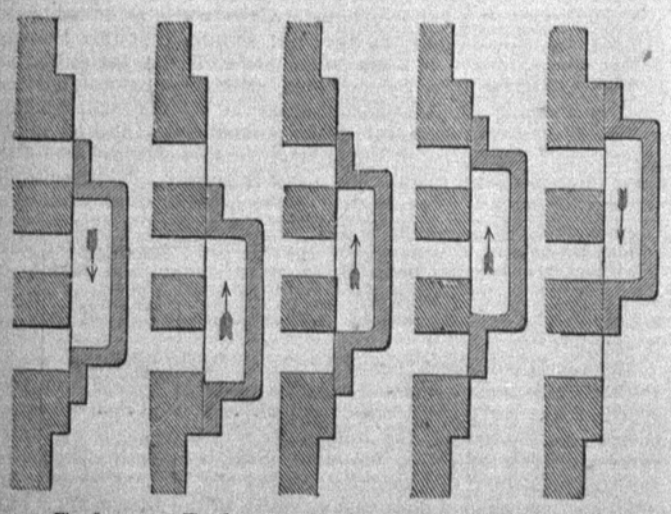


Fig. 5. Fig. 6. Fig. 7. Fig. 8. Fig. 9.

When the eccentric has advanced from *f* to *e*, the crank will have reached the point *g*; the piston is therefore at *a* when the port *c e* is fully open, the slide being then in the position fig. 6.

Again,—when the eccentric has reached the point *h*, the port *c e* will be re-closed (fig. 5), and *i* will be the position of the piston; therefore, the distance of the piston from the end of its stroke, when the steam is cut off, is proportioned to the whole stroke, as *i e* is to *d e*.

When the eccentric arrives at *k*, the slide will occupy its central position (fig. 7), and the piston will be at *m*, where exhaustion commences from above it; but steam is not admitted below it, for the return stroke, until the eccentric has reached the point *n*, where the port *a d* begins to open, the position of the slide at that moment being that shown in fig. 8.

When the eccentric arrives at *d*, the port will be fully open, the slide being then in its extreme position, fig. 9; and it will be re-closed when the eccentric arrives at *g*, and the piston at *p*, where the steam is cut off, the position of the slide being again that shown in fig. 8. Again,—when the eccentric reaches the point *r*, exhaustion ceases from above the piston, which is then at *s*, and commences from below it, the slide being then in its central position, fig. 7, and moving downward. Finally,—the crank having arrived at *d*, and the eccentric at *f*, the piston will have completed its ascent, and the slide will occupy the position fig. 5, as at starting.

The steam was shown to be cut off when the piston had descended from *d* to *i*, the crank having described the arc *d g u*, and the eccentric the arc *f e h*. Now, *d i* is the versed sine of *d g u*, and *e c* is the versed sine of half *f e h*; and *d g u* and *f e h* are equal arcs. Hence

RULE III.—*To find at what part of the stroke steam will be cut off with a given amount of lap:*—

Divide the width of steam port, by itself, plus the lap, and call the quotient versed sine. Find its corresponding arc in degrees and minutes, and call it arc the first. If arc the first be less than 45 degrees, multiply the versed sine of twice that arc by half the stroke in inches, and the product will be the distance of the piston from the *commencement* of its stroke, when the steam is cut off.

If arc the first exceed 45 degrees, multiply the versed sine of the difference between double that arc and 180 degrees by half the stroke, and the product will be the distance of the piston from the *end* of its stroke when the steam is cut off.

RULE IV.—*To find the amount of lap necessary to cut off the steam at any given part of the stroke:*—

If it be required to cut off the steam before half-stroke, divide the distance the piston moves before steam is cut off, by half the stroke, and call the quotient versed sine. Find the arc of that versed sine, and also the versed sine of half that arc. Divide the difference between the versed sine last found and unity, by the versed sine, and multiply the width of steam port by the quotient; the product will be the lap.

If it be required to cut off the steam at a point beyond half-stroke, divide the distance of the piston from the end of its stroke, when steam is cut off, by half the length of stroke; call the quotient versed sine; find its corresponding arc, and subtract it from 180 degrees. Find the versed sine of half the remainder, and subtract it from unity. Divide the remainder by the versed sine, and multiply the width of the steam port by the quotient; the product will be the lap.

Example 3.—The stroke of a piston is 36 inches; width of steam port 1½ inch; and lap 6 inches: required the point of the stroke at which steam will be cut off.

Here $1{\cdot}5 + 6 = 7{\cdot}5$; and $1{\cdot}5 \div 7{\cdot}5 = {\cdot}2$ = versed sine;
arc of versed sine ·2 = 36° 52′ (arc the first);
and $36° 52' \times {\cdot}2 = 73° 44'$ = arc of versed sine, ·7198.

Then $7198 \times 18 = 12{\cdot}95$ inches = distance of the piston from the commencement of its stroke when the steam is cut off.

Example 4.—The stroke of a piston is 36 inches; width of steam port 1½ inch; and extent of lap 1¼ inch: required the point of the stroke at which steam is cut off.

Here $1{\cdot}5 + 1{\cdot}25 = 2{\cdot}75$; and $1{\cdot}5 \div 2{\cdot}75 = {\cdot}5454$ = versed sine of arc 62° 58′ (arc the first).

Then $62° 58' \times 2 = 125° 56'$; and $180° - 125° 56' = 54° 4'$ = arc of versed sine, ·4131; $4131 \times 18 = 7{\cdot}43$ inches = distance of the piston from the end of its stroke when the steam is cut off.

Example 5.—The stroke of a piston is 36 inches; width of steam port 1·5 inches; and distance of the piston from the commencement of its stroke, when the steam is cut off, 12·95 inches: required the lap.

Here $12{\cdot}95 \div 18 = {\cdot}7198$ = versed sine of arc 73° 44′;
$73° 44' \div 2 = 36° 52'$ = arc of versed sine ·2.

Then $1 - {\cdot}2 = {\cdot}8$; and $8 \div 2 = 4$; $1{\cdot}5 \times 4 = 6$ inches = lap.

Example 6.—The stroke of a piston is 36 inches; width of steam port 1·5 inches; and distance of piston from the end of its stroke, when steam is to be cut off, 7·43 inches: required the lap.

Here $7{\cdot}43 \div 18 = {\cdot}4131$ = versed sine of arc 54° 4′.

Then $180° - 54° 4' = 125° 56'$; and $125° 56' \div 2 = 62° 58'$ = arc of versed sine ·5454.

$1 - {\cdot}5454 = {\cdot}4546$; and $\cdot4546 \div \cdot5454 = {\cdot}8335$;

$\cdot8335 \times 1{\cdot}5 = 1{\cdot}25$ inches = lap.

Exhaustion was shown to commence when the piston was at *m* in its descent, and at *s* in its ascent; *l* and *t* being the corresponding positions of the crank at those times. Now *d* and *f* were the respective starting points of the crank and eccentric; and the arc *d g l*, described by the crank, is equal to the arc *f e k*, described by the eccentric. Therefore, *r f* and *e l* are equal arcs. Hence,

To find the distance of the piston from the end of its stroke when exhaustion commences, subtract arc the first (found by Rule III.) from 90 degrees, and multiply the versed sine of the remainder by half the stroke. The product will be the distance required.

Example 7.—Arc the first (Example 3) = 36° 52′; and 90° − 36° 52′ = 53° 8′ = arc of versed sine ·4

Then $\cdot4 \times 18 = 7{\cdot}2$ inches, the distance required.

Example 8.—Arc the first (Example 4) = 62° 58′; and 90° − 62° 58′ = 27° 2′ = arc of versed sine ·1092.

Then $\cdot1092 \times 18 = 1{\cdot}9656$ inches, the distance required.

From the foregoing examples, it is obvious that whatever may be the relative proportions of the length of stroke and width of steam port, the lap must be some multiple of the port, that the steam may be cut off at any given point of the stroke.

The annexed table exhibits a series of multipliers for determining the amount of lap necessary to cut off the steam at any part of the stroke from $\frac{1}{8}$th to $\frac{7}{8}$ths, *when the slide has no lead.*

		Multipliers.
Portion of the stroke to be performed by the piston before the steam is cut off.	$\frac{1}{8}$th	14·48
	$\frac{2}{8}$	6·46
	$\frac{3}{8}$	3·77
	$\frac{4}{8}$	2·41
	$\frac{5}{8}$	1·58
	$\frac{6}{8}$	1·00
	$\frac{7}{8}$	·54

We shall next month proceed to examine the conditions of the slide valve with both "lead and lap."

R. B. C.

HEALTH OF TOWNS—THE GOVERNMENT AND THE PROFESSION.

Now that the sanitary movement is likely to bear fruit, it will be well for our professional readers to turn their attention to the share which they are to have in the rewards, after having borne their part of the labour. While engineers, architects, and surveyors have been working hard in carrying out sanitary reform, in improving the drainage, in reducing the cost of sewers, in mitigating the smoke nuisance, in warming, in ventilating, in the construction of dwellings, in the application of sewage manures, and in many other ways,—medical men and members of parliament have been making speeches, and claiming the honours of the campaign, as it seems they claim the emoluments. With what justice members of the constructive professions can be kept out of sight, we do not know; but there is a determined set on the part of the medical men to keep them out, and to monopolise the merit and the patronage. Of the five Metropolitan Sanitary Commissioners, two are medical men, viz., Dr. Southwood Smith and Professor Owen; and not one is engineer, architect, or surveyor. The commissioners, at page 51 of their First Report, speak as follows:—

"It has appeared to be our duty to state, that we have had presented to us ground of exception against one class of appointments to these commissions, namely, that of surveyors, of architects in practice, of builders, traders, agents, and professional persons connected with building operations in their respective districts."

We think the bias of this passage is readily to be seen, though it does not impugn the appointment of engineers, architects, or surveyors, as paid commissioners, such officers not practising. There is no reason given why an architect and an engineer should not be appointed on the Metropolitan Sanitary Commission in addition to the physician and surgeon, or naturalist. We will show afterwards what reason there is why the two former should be appointed.

The following paragraph of the Report contains an insinuation, well worthy of notice, for it has its object:—

"The more the investigation advances, the more is it apparent that the progressive improvement and proper execution of this class of public works, together with the appliances of hydraulic engineering, cannot be reasonably expected to be dealt with incidentally, or collaterally to ordinary occupation, or even to connected professional pursuits, but require a degree of special study which not only place them beyond the sphere of the discussion of popular administrative bodies, but beyond that of ordinary professional engineering and architectural practice. In justification of this conclusion, and to show the evil of the perverted applications of names of high general professional authority, we might adduce examples of the most defective works which have received their sanction."

The aim of this is, that the abuse shall be an argument against the use: because some architects have laid down expensive sewers, engineers, architects, and surveyors shall be excluded; because Professor Donaldson and Mr. Joseph Gwilt approve of the old system, those who have fostered and executed the new system shall not be employed. This is what the commissioners mean, though they do not say it fully; and we put it to the public whether it is fair to professions, which by their talent and their intelligence have so much contributed to the reputation of the country.

It may be taken as a matter of course that Crown Commissioners recommend the employment of the government Caleb Quotem, "the Corps of Royal Engineers," to execute a survey of the metropolitan districts. This we conceive to be the finishing touch to the wrongs and insults which the Sanitary Commissioners have in this Report, and in their proceedings, heaped upon highly honourable professions.

If it be needful to show that engineers, architects, and surveyors can be of some use, we shall appeal to the Report of the Sanitary Commissioners, the recommendations in which are based on the evidence of Mr. Roe, the Surveyor of the Holborn and Finsbury District, Mr. Phillips, the Surveyor of the Westminster District, and other able officers. In truth, as our pages would show, Mr. Roe has, by his indefatigable exertions, already carried out much of the plans now advocated by the Sanitary Commissioners, and has only been prevented by the Commissioners of Sewers from doing more. Surely these officers are to be balanced against those who have adhered to a practice which has only recently been opposed and condemned. What do the commissioners tell us?

"All the improvements which the public have yet obtained in this branch of public works, have been the result of the special and undivided practical attentions of well-qualified paid officers, and it appears to us that further improvement must be sought by the same means, and that one of the chief objects of future administrative arrangements must be to secure, protect, and encourage the zealous, undivided attention and efficient labour of such officers."

If engineers and surveyors have already effected "all the improvements which the public have yet obtained in this branch of public works;" and if to them, as scientific officers, the public have to look for future improvements, we can see no reason for the slur cast on them by their exclusion from the present commission, by the announced exclusion from future commissions, and by the employment of the Corps of Royal Engineers, of whom—with all respect be it said—the reputation is not European. We cannot hold the appointment of Mr. Austin to the secretaryship of the commission, nor the compliment paid to the executive officers of the Commissioners of Sewers as any alleviation of the intended slight. We hope Mr. Edwin Chadwick, as commissioner, and Mr. Austin, as secretary, both of whom have done well in the cause of sanitary reform, have had no part in the exclusive policy of the commission.

We have the highest regard for the medical profession; we have the strongest feeling of the good it has done in promoting sanitary reform; but we cannot stand still while medical men arrogate to themselves the merits, the honours, and the rewards of sanitary reform. Their agitation has done good, we admit; their disinterested advocacy of the cause claims the highest praise; their evidence has given a body and strength to the movement; but it is our professions which have worked while theirs have talked,—which have improved the forms of the sewers, and reduced the price—which have cleansed them by flushing, and which by a mass of individual labour have perfected and carried out plans of improve-

ment in every branch of construction, ministering to the public comfort, health, and life. Our pages have had their share in these discussions, and we have co-operated with our professional readers in carrying out a measure of reform, which is already great. In the Holborn and Finsbury and Westminster divisions of sewers alone, a reform has been effected, such as has not yet been seen in these matters; and we are ignorant of the share the medical profession have taken in carrying them out.

Within a period not very distant, the new Sanitary Commissioners, or Commissioners of Sewers, will lay down works to the amount of half a million, perhaps a million sterling, upon the advice, it is true, of competent professional officers, though under what competeut supervision on the part of the commission, we are unaware. When Mr. Roe proposes his plan for spending a quarter of a million in getting a new outfall, which of the commissioners will consider it his special department to examine the estimates, and share in their responsibility? It will not be Lord Robert Grosvenor—it will not be Mr. Edwin Chadwick, great as is his capacity as an administrator—it will not be Mr. Richard Lambert Jones, though he is Chairman of the Bridge Committee in the City—it will not be Dr. Southwood Smith or Professor Owen. The two latter will, we apprehend, be of little use in matters like these, and will take no part in them. Thus, a member of parliament, a naturalist, a barrister, an auctioneer, and a physician, are to superintend the disbursement of hundreds of thousands of pounds in public works, and to appoint "well-qualified paid officers" in the engineering and surveying departments; who are to have "a degree of special study which [shall] not only place them beyond the sphere of the discussion of popular administrative bodies, but beyond that of ordinary professional engineering and architectural practice."

The government have not thought it necessary to give a fair representation to the profession in the new Commission of Sewers, though the names of Mr. Robert Stephenson, M.P., Mr. Locke, M.P., Mr. George Rennie, Mr. Cubitt, and others, are well enough known at Whitehall.

The constitution of the Metropolitan Sanitary Commission is, in reference to the sphere of its future duties, more monstrous than that of the Railway Commission, where three parties, who know nothing of railways—a member of parliament, an East India judge, and an officer in the army—are entrusted to meddle with railway works and administrations. We have so many of these absurd appointments of late, that we have a strong impression that unfitness is adopted as the government rule for office, and have some expectation of seeing Monsieur Jullien prime minister. Why the engineering profession should be exposed to the contumely and neglect from which it suffers at the hands of the government, we do not know; but the enumeration of the Railway Commission, the Tidal Harbour Commission, and the Metropolitan Sanitary Commission, is a sufficient proof that a degree of unfairness is displayed, which demands immediate and effective opposition. Although the reputation of English engineers is well known to the world—although their professional skill is sought in every country—it may be that they are thought by the home government a body too inconsiderable and contemptible to withstand oppression or demand fair play.

The misconduct of the government on this head has reached that height, that the professions, if they wish to maintain their public character, cannot do otherwise than take instant steps to obtain justice. They have no security at present for the appointment of competent commissioners, or efficient officers, or for the employment of professional men at all; there is no security that officers of the Royal Engineers, and other branches of the army, will not be appointed surveyors of the sewers and other public works, the present officers being superseded. We think it is the duty of the Institutions of Architects and Civil Engineers to call meetings of their members, to memorialise the government, and send deputations to Whitehall, and take every other necessary step to vindicate the rights of their members. Aggregate meetings of engineers, architects, and surveyors, should be held in the metropolis, and in provinces petitions sent to parliament, and memorials to the Treasury. The members of parliament interested in the welfare of the professions, should be requested to take steps in parliament for obtaining explanations from the ministers. Mr. Robert Stephenson, Mr. Locke, and Mr. Cubitt, would no doubt, on application, give their cordial support to any necessary measure.

While we urge these strong remarks on the injustice done to engineers by the Metropolitan Sanitary Commissioners, it must not be thought that we undervalue their Report on the practical points to which they apply themselves. We are glad to acknowledge it as a step forward in the right way.

THE FAN BLAST.

Series of Experiments relative to the Fan Blast, presented by Mr. BUCKLE, *of the Soho Works, to the meeting of the Institute of Mechanical Engineers, Birmingham, May* 17, *and October* 27, 1847.

(PAPER No. 1.)

The subject of this paper has reference to a portion of a series of experiments on the Fan Blast,—a subject which many members of this Institution are conversant with; but it is hoped that hints here thrown out may be serviceable in leading to such constructions of the fan as shall insure the greatest useful effect with the least expenditure of power. The fan has become an indispensable machine in smithies and foundries, it abridges time and labour, and is otherwise a great improvement over the old system of bellows. The uniform stream of the former admits of no comparison, by the puffy blasts of the latter. By means of the fan the smith can heat his work with precision; he can vary at discretion the size of his nozzle tweyere, without deteriorating the density of his blast. He can conveniently heat one piece of work while shaping another.

In a well-regulated smithy, the main pipe from the fan is furnished with an air chest and with nozzle pipes, varying from one to three inches diameter. The pressure of the blast is made to range from four to five ounces per square inch. A nozzle pipe of $1\frac{5}{8}$ inch diameter is found a suitable size for general engine forcings.

The position of the fan in its chest, or the one preferred and generally made use of, is an eccentric position. The continual increasing winding passage between the tips of the vanes and the chest, serves to receive the air from every point of its circumference, and forms, as it were, a general accumulating stream of air to the exit pipe. The particles of air having passed the inlet opening, and entering on the heel of the blade, would retain the same circular path were it not for the centrifugal force of the air due to its weight and velocity, impelling them forward towards the tips of the vanes; and this continued action is going on, particle following particle, till they are ultimately thrown against the fan chest, and are impelled forward to the exit pipe. It is by this centrifugal action that the air becomes impelled and accumulated into one general stream. But, as will be presently shown, there is a certain velocity of the tips of the fan which best suits this action.

An ordinary eccentric-placed fan, 4 feet diameter—the blades 10 inches wide and 14 inches long—and making 870 revolutions per minute, will supply air at a density of 4 ounces per square inch, to 40 tweyeres, each being $1\frac{5}{8}$ inches diameter, without any falling off in density. The experiments herein detailed were made with a fan 3 feet $10\frac{3}{8}$ inches diameter, the width of the vanes being $10\frac{3}{4}$ and the length 14 inches; the eccentricity of the fan $1\frac{7}{16}$ inches, with reference to the fan case, the number of vanes being 5, and placed at an angle of 6° to the plane of the diameter; the inlet openings on the side of the fan chest $17\frac{1}{2}$ inches diameter, the outlet opening 12 inches square; the space between the tips of the blades and the chest increasing from $\frac{3}{8}$ inch on the exit pipe to $3\frac{1}{2}$ at the bottom, in a line perpendicular with the centre. To the blast pipe leading to the tweyeres a slide valve was attached, by means of which the area of the discharge was accurately adjusted to suit the required density.

The guage to indicate the density of the air, was a glass graduated tube, primed with water, it being more sensitive and having a greater range than the mercurial one.

These experiments were made with a view to ascertain what density of air could be obtained, with the vanes moving at given velocities, the outlet pipe being closed, and also at given velocities with the outlet open; but its area varied at discretion. And further, to ascertain the horse-power required to drive the fan under the varied condition.

The horse-power was ascertained by an indicator, the friction of engine and gearing being deducted in each experiment. With reference to the term Theoretical Velocity, as used in the table, it may be necessary to observe, that thereby is meant the velocity which a body would acquire in falling the height of a homogeneous column of air equivalent to the required density. Having given the necessary preliminary explanations of the blast above that of the atmosphere, we come to the experiments as recorded in the table, No. 1 *a*.

The first column is the number of experiments.
The second is the number of revolutions of the fan per minute.
The third is the velocity of the tips of the vanes in feet per second.
The fourth is the density of the air in ounces per square inch, as indicated by the gauge.
The fifth is the area of the discharge pipe in inches.
The sixth is the indicated horse power.

By this paper it is intended to be shown that there are certain velocities with which the tips of the vanes of a fan should move according to the required density of air, and that there are certain laws which govern these velocities.

First.—Water is 827 times heavier than air; mercury is 13·5 heavier than water: consequently, mercury is 11164 heavier than air. A column of mercury, one inch in height, would therefore balance a column of air 11164 inches, or 930·3 feet in height. Let A be a column of mercury equal in height to any given density, and let B represent 930·3, and C 64[*]; then $\sqrt{(A \times B \times C)} = V$ or the velocity that a body would acquire in falling the height of a column of air equivalent to the density.

Second.—The centrifugal force of air coincides with the results obtained by the laws of falling bodies, that is when the velocity is the same as the velocity which a body will acquire in falling the height of a homogeneous column of air equivalent to any given density. To obtain the centrifugal force or density of air apply the following general rule.

Having given the velocity of the air, and the diameter of the fan, to ascertain the centrifugal force,—

Rule.—Divide the velocity by 4·01, and again divide the square of the quotient by the diameter of the fan. This last quotient multiplied by the weight of a cubic foot of air, at 60° Fahrenheit, is equal to the force in ounces per square foot, which, divided by 144, is equal to the density of air per square inch. Or, substituting the following formula, we have

$$D = N\,V \times \cdot 000034$$

where D is the density of the air in ounces per square inch, and N the number of revolutions of fan per minute, and V the velocity of the tips of the fan in feet per second.

Let us now compare the results of the foregoing table. To do this, we will first take the velocity of the tips of vanes per second, and the power necessary to drive the fan. We will first take Nos. 1, 2, 3, 4, 5, and 6, and we shall find by inspecting the table that the corresponding velocities to these numbers are 236·8, 220·8, 202·1, 185·2, 171·5, and 144·1, and the corresponding densities of air per square inch are 9·4, 7·9, 6·9, 5·6, 4·5, and 3·5 ounces. The fan, it must be understood, is discharging no air; the velocity of the fan is merely keeping the air at a certain density or pressure per square inch. Under these circumstances, it requires a certain velocity of the tips of the fan to maintain a certain density of air, but not in a direct ratio.

The law which governs the velocity of the tips of the fan appears from these experiments to be $\frac{9}{10}$ of the velocity a body would acquire in falling the height of a homogeneous column of air equivalent to the density. This we have called the theoretical velocity, and by comparing Nos. 1, 2, 3, 4, 5, and 6 experiments as above, that is, by comparing the velocity of the tips of the fan per second with $\frac{9}{10}$ of the theoretical velocity, we shall find them to agree tolerably near. Thus, if the velocity of the tips of the fan per second be represented by 1, then $\frac{9}{10}$ of the theoretical velocity will be represented by

1·004	in No. 1	experiment,	The mean 1·008
·986	2	,,	
1·008	3	,,	
·990	4	,,	
·960	5	,,	
1·0007	6	,,	

But we shall not only find that the $\frac{9}{10}$ of theoretical velocity governs the fan when it is not discharging air, but that the theoretical velocity governs it also when the outlet pipe is open; that is, that the maximum effect of the fan is when the vanes move from the theoretical velocity to $\frac{9}{10}$ of that velocity due to the density of the air, that the greatest quantity of air is discharged by the fan under these conditions with the least expenditure of power. To illustrate this more fully, let us refer to the table of experiments, and for our example we will take Nos. 9, 10, and 11; here the density in each is six ounces. In No. 10 the velocity of the tips of the vanes is 213·33 feet per second, while the theoretical velocity is 211 feet per second, being nearly the same. The quantity of air discharged is 77·9 cubic feet per second, and the power employed in this case amounts to 12·5 horses.

We take now No. 11 experiment. Here the velocity of the tips of the fan is 192 feet per second, and $\frac{9}{10}$ of the theoretical velocity 190 feet per second. Now these two experiments are in proportion to each other nearly, viz., in No. 11 the quantity of air discharged amounts to 35·7 cubic feet per second, and takes 6·4 horse power, while No. 10 discharges 77·9 cubic feet per second, and takes 12·5 horse-power. Thus the discharge of air is nearly 2 to 1, and the horse-power employed in the same proportion.

In the following examples we shall call the theoretical velocity per second *unity*, beginning with No. 15. In this example we shall also call the quantity of air discharged in cubic feet per second unity, and also the horse-power.

	Theoretical Velocity.	Density of Air per sq. in.	Velocity of tips of Fan.	Quantity of Air discharged.	Horse-power.
No. 15	1	5 oz.	·906	1·	1
14	1	5	1·007	2·34	1·93
12	1	5	1·150	2·67	3·16
20	1	4	900	1	1
19	1	4	1·029	2·4	3·42
18	1	4	1·133	2·02	3· nearly
17	1	4	1·225	2·30	4
16	1	4	1·280	2·12	4·27
11	1	6	·913	1·	1
10	1	6	1·009	2·18	2 nearly
23	1	3	1 050	1·59	2·53
22	1	3	1·160	2·	3·56
21	1	3	1·338	1·47	3·40
7	1·028	1·	1	1·	1·
9	·950	·857	1	1·203	1·03
12	·869	·714	1	1·35	1·06
16	·777	·571	1	1·40	1·11

To give a further illustration of this part of our subject, we will take Nos. 7, 9, 12, and 16 experiments. Here the velocity of the tips of the fan is the same, which we shall denote unity. The corresponding densities are 7, 6, 5, and 4 ounces; we shall call the highest unity, also the cubic feet discharged per second, and the horse-power.

Nearly all the preceding examples justify our conclusion, that the greatest results are obtained when the theoretical velocity and the tips of the vanes are nearly equal. It carries its own conviction that if we increase the velocity of the tips of the vanes, and only double the cubic quantity of air delivered, that it must take more than double the expenditure of power, the density of air remaining the same.

We shall now give examples of the *data* dictated by our table of experiments. And first, having given the density of air per square inch to determine the velocity of the tips of the vanes per second; also the horse power requisite to drive the fan under these circumstances, the fan not discharging air, but its velocity merely keeping the air at a certain density.

Let D denote the density of the air in ounces per square inch, and A a column of mercury equivalent in height to that density. Then by the laws of falling bodies $\sqrt{(A \times 930{\cdot}3 \times 64)} = V$ the velocity acquired by a body falling through a column of air of the corresponding density.

Then $\frac{38 \times D}{16} = P$ the number of pounds acting on the vanes, and $\frac{\frac{9}{10}\,V. \times 60\,P.}{33000} = H.\,P.$ or horse-power required.

The constant number 38 is obtained by the following formula.

$$\frac{H\,P \times 33000}{\frac{9}{10}\,V \times 60} = P. \quad \text{Then } \frac{P \times 16}{D} = 38$$

Example.—Let D = 9·4 oz. per square in., and A = 1·175 in. of mercury, to determine the velocity of the tips of the vanes per second, and also the horse-power.

Then $\sqrt{(930{\cdot}3 \times 64 \times 1{\cdot}175)} = 264{\cdot}4$, the theoretical velocity, $\frac{9}{10}$ of which is = 237·96 = V, or velocity of tips of vanes per sec.

Now $\frac{38 \times 9{\cdot}4}{16} = 22{\cdot}32 = P$, or pounds acting on the vanes of fan.

Then $\frac{237{\cdot}96 \times 60 \times 22{\cdot}32}{33000} = 9{\cdot}6$ the horse-power required.

Having given the velocity of the air in feet per second (or as it has been termed the theoretical velocity) to determine the density of the air in accordance with the laws of centrifugal force.

Let the velocity be 264·4 feet per sec., and the diameter of the fan 3·9 feet. Then by former rules we have

$\frac{264{\cdot}4}{4{\cdot}01} = 66{\cdot}2$ and $\frac{66{\cdot}2^2}{3{\cdot}9} = 11169 =$ and $\frac{11169 \times 1{\cdot}209}{144} =$ 9· ounces density, the answer required.

Or by the second rule, take the velocity of the fan in feet per second, multiplied by the number of revolutions of the fan per minute, the product multiplied by ·000034 = the density required.

Here we must remark, that according to our table of experiments, that when the tips of the vanes are to move at $\frac{9}{10}$ of the theoretical velocity, that not more than 220 lb. of air are discharged per minute; but this is without any attenuation in the density.

* The space which a gravitating body will pass through in one second is $16\frac{1}{12}$ feet; but by the principle of accelerating forces, the velocity of a falling body in any given time is equal to twice the space through which it has passed in that time, or the velocity is equal to the square root of the number obtained by multiplying 64 by the height in feet.

To determine the horse-power necessary to drive the fan when discharging air, the velocity of the tips of the vanes not to exceed $\frac{9}{10}$ of the theoretical velocity, having given the density of air required, also the cubic feet,

First find the horse-power, as directed in former examples, when the fan is not discharging air.

Then multiply $\frac{1}{10}$ part of the weight of air to be discharged by the fan per minute in pounds by $\frac{9}{10}$ of the theoretical velocity, and *divide* by 33000. The quotient will give the horse-power necessary to discharge this quantity of air, which *add* to the horse-power necessary to drive the fan when not *discharging air*, for the answer required.

Example.—Let D be the density of air required = 4 oz. A, a column of mercury equal to the density = ·5 and W = the weight of air to be discharged = 220 lb. per minute, and V $\frac{9}{10}$ the velocity of fan in feet per minute.

$$\frac{38 \times 4}{16} = 9{\cdot}5 = \text{P} = \text{the pounds acting on the vane.}$$

Then by former rule, $\text{V} = \frac{9315{\cdot}0 \times 9{\cdot}5}{33000} = 2{\cdot}67$ horse-power necessary to drive the fan without efflux.

Now a cubic foot of common air at 60° Fahrenheit weighs 1·209 oz., therefore a cubic foot of the given density will be equal to 1·511 oz., and $\frac{220 \times 16}{1{\cdot}511} = 2330$ feet = the cubic quantity of air discharged per minute. And $\frac{220}{60} = \frac{3{\cdot}66 \times 9315{\cdot}0}{33000} = 1{\cdot}0$ horse-power necessary to discharge the given weight of air, and 1·0 + 2·67 = 3·67 = the total horse-power required.

When the velocity of the tips of the vanes is to move equal to the theoretical velocity, then we proceed as in the last examples, only we take $\frac{1}{10}$ instead of $\frac{1}{16}$ (as in former examples) of the weight of air discharged, which added to the horse-power requisite to drive the fan when no efflux takes place.

We should here again remark, that when the fan is moving at this velocity, that it is capable of discharging 480 lb. of air per minute without any falling off in density.

In a recent set of experiments, the inlet openings in the sides of the fan chest were contracted from 17½, the original diameter, to 12 and 6 in. diameter, when we obtained the following results.

First, that the power expended with the opening contracted to 12 in. diameter, was as 2⅝ to 1 compared wiih the opening of 17½ in. diameter; the velocity of the fan being nearly the same, as also the quantity and density of air delivered.

Second, that the power expended with the opening contracted to 6 in. diameter, was as 2½ to 1 compared with the opening of 17½ in. diameter; the velocity of the fan being nearly the same, and also the area of the efflux pipe, but the density of the air decreased one-fourth.

These experiments show that the inlet openings must be made of sufficient size, that the air may have a free and uninterrupted action in its passage to the blades of the fan, for if we impede this action we do so at the expense of power.

(PAPER No. 2.)

In resuming the subject of the fan blast, I shall endeavour, as far as I conveniently can, to avoid detailed statements of the pneumatic laws involved in its consideration, as they would occupy more time than would be consistent with the present occasion; and shall proceed to remark on the most important points connected with the construction of the fan, viz.: the adoption of such forms and proportions, as shall insure the greatest results with the least expenditure of power; and effect a diminution of the intolerable noise that generally arises from the working of the fan. And although I have not been able to carry out such leading principles to the fullest extent, I trust that I have furnished materials that will be found of value to those members whose greater leisure may enable them to do so.

From a contemplative view of the action and apparent effect of that very useful apparatus, a fan blast, it would appear that the air in the fan case is impelled by the vanes along the transit pipe, or channel, to the chest provided for the blast; and that the continuous rapid motion of the vanes, compresses air in the pipe and chest, to a degree that may be shown and accurately measured, by a water, or mercurial gage, attached to the blast chest.

In my first communication, the principal investigation rested on a theoretical question, viz.: whether the tips of the blade should partake of the same velocity as a body falling freely a certain height, such height being governed by the density of air required. Recent experiments (the results of which accompany this paper) justify the conclusions then made, as will be seen on examining tables Nos. 2 *a*, 3 *a*, and 4 *a*.

Having satisfied myself with respect to the velocity a fan ought to have, when a certain density of air is required, I purpose in this paper to examine the fan under other varied conditions, the object being to establish the best proportions of inlet openings in the sides of the fan chest, and the suitable corresponding length of vanes. For this purpose, I caused the openings in the sides of the fan chest to be made of a large diameter, and I was enabled to vary those openings, by fitting in rings of wood; and I varied the fan by attaching to its arms, vanes of corresponding lengths. The experiments are classed in the following tables:—

Table No. 1 *a*, Contains the first set of experiments.
" 2 *a*, Experiments made with an inlet opening 30 inches diameter; the length of vane being reduced to 8 inches.
" 3 *a*, With an inlet opening of 24⅜ inches diameter, and the length of the vane 11 inches.
" 4 *a*, With an inlet opening of 20⅛ inches diameter, and the length of the vane 13⅜ inches.
" 1 *b*, Shows the effect produced by narrowing the blades to 6 inches, the length being 16 inches, with outlet to transit pipe 4 inches deep.
" 2 *b*, 3 *b*, 4 *b*, are experiments showing the effect produced by contracting the outlet opening. The inlet opening, and the length of vane, being the same as the table under which it is classed.

In the concluding part of the first paper it was stated that, by impeding the free admission of air into the vane, it was done at the expense of power. Thus, by contracting the inlet opening to 12 inches diameter, we expended more than twice the power. This led to an extension of the openings, the results of which will be seen on comparing the former state of the fan, in table No. 1 *a*, with the present tables Nos. 2 *a*, 3 *a*, and 4 *a*.

In the first five experiments, no efflux of air takes place; and if, in these experiments, we take the mean of the density of the air and the horse-power, and call them *unity*, their proportions with the corresponding experiments represented in tables 2, 3, and 4, will stand thus:

Table No.	1	1·	Density of air.	1·	Horse-power.
"	2	·69	"	1·21	"
"	3	·8	"	·9	"
"	4	1·	"	1·10	"

Here the results are in favour of the fan in its original shape, and similar results appear when the fan is discharging air.

I will now proceed to examine the inlet opening, and the best length of vane.

From the experiments enumerated in the tables it will be seen that the longer vane possesses a preponderating power over the shorter one, in condensing air of the greatest density, with the least proportion of power. Thus, with a vane 14 inches long, the tips of which revolve at the rate of 236·8 feet per second, air is condensed to 9·4 ounces per square inch above the pressure of the atmosphere, with a power of 9·6 horses; but a vane 8 inches long, the diameter at the tips being the same, and having, therefore, the same velocity, condenses air to 6 ounces per square inch only, and takes 12 horse-power.

Thus, the density of the latter is little better than $\frac{6}{10}$ of the former, while the power absorbed is nearly 1·25 to 1. Although the velocity of the tips of the vanes is the same in each case, the velocity of the heels of the respective blades are very different; for whilst the tips of the blades in each case move at the rate of 236·8 feet per second, the heels of the 14 inch blades move at the rate of 90·8 feet per second; and the heels of the 8 inch move at the rate of 151·75 feet per second; or, the velocity of the heel of the 14 inch, moves in the ratio of 1 to 1·67, compared with the heel of the 8 inch blade. The longer blade approaching nearer the centre, strikes the air with less velocity, and allows it to enter on the blade with greater freedom, and with considerable less force than the shorter one. The inference is, that the short blade must take more power at the same time that it accumulates a less quantity of air.

These experiments lead me to conclude that the length of the vane demands as great a consideration as the proper diameter of the inlet opening. If there were no other object in view, it would be useless making the vanes of the fan of a greater width than the inlet opening can freely supply.* On the proportion of the length and width of the vane, and the diameter of the inlet opening, rest the three most important points, viz.: *quantity*, and *density* of air, and expenditure of *power*.

* The proportion a suction pipe bears to a pump, is an anagalous case; for, if we drive the bucket at a greater velocity than the suction pipe will supply it with water, the consequence will be, that we shall not lift so much water, at the same time that we absorb more power.

TABLES OF EXPERIMENTS.

No. 1, a.—With Inlet opening 17½ in. diam., and Vanes 14 in. long, by 10⅜ in. wide.

No. of Experiment.	Number of Revolutions of Fan, per Minute.	Velocity of the tips of Vanes in feet per Second	Density of the Air, in ounces, per square inch.	Area of Discharge pipe, in sq. inches.	Indicated Horse Power.
1	1160	236·8	9·4	0	9·6
2	1081·6	220·8	7·9	0	7·54
3	1000	204 16	6 9	0	6·68
4	907·5	185 28	5·6	0	5·36
5	840	171 5	4·5	0	3·82
6	705·8	144·1	3·5	0	2·21
7	1086·6	221·8	7	37·5	13 31
8	1063·3	217·09	7	38·12	11·92
9	1086 6	221·8	6	48·75	13·81
10	1045	213 33	6	53·12	12·54
11	941·6	192 2	6	24·37	6·43
12	1086·6	221·8	5	60	14·26
13	1035 8	211 5	5	65	13·05
14	950	193·9	5	52·5	8·75
15	855	174·5	5	22 5	4·53
16	1086·6	221·8	4	69·3	14·19
17	1035 8	211·48	4	75	13·3
18	96 6 6	196·6	4	65·6	9·5
19	870	177·6	4	78·1	11·3
20	760	155·8	4	33·1	3·3
21	985·3	200·7	3	82·6	10·15
22	885	174·5	3	92·7	10·6
23	773·3	157·8	3	189·6	7·56
24	659·2	134·5	3	56·2	2·98

No. 1, b.—With the Outlet opening contracted to 4 in. deep, and 7 in. wide. Inlet opening 15 in. diameter. Vane 16 in. long, by 6 in. wide.

No Efflux	800	163·3	4·5	0	2·38
	885	180·7	5·7	0	2·89
With Efflux.	786·6	160·5	4·0	13·75	2·9
	885	180·7	4	25	4·76
	870	177·6	5	10	3·5
	773·3	157·8	3	37·5	3·2
	878·5	159·1	3	35	5·0

No. 2, a.—With Inlet opening 30 in. diam. Vane 8 in. long by 10⅜ in. wide.

Number of Revolutions of Fan, per Minute.	Velocity of the Tips of Vanes in feet per Second.	Density of the Air in ounces, per square inch.	Area of Discharge Pipe, in sq. inches.	Indicated Horse Power.
1160	236·8	6	0	11·92
1081·6	220·8	5·3	0	10·5
1000	204 16	5	0	7·65
900	183·78	4·3	0	5·54
786	160·59	3·3	0	4·42
1170	238·8	5	30·62	12·02
1160	236·8	4	53·7	12·4
1081 6	220·8	4	46·2	10·4
966·6	196·6	4	60	11·2
878·5	179·1	4	40	6·6
1100	224·5	3	63·7	9·23
966·6	196·6	3	99·6	10·25
878·5	179·1	3	68·7	8·84
780	159 2	3	57·5	6·55

No. 2, b.—With the Outlet opening contracted to 4 in. deep.

No Efflux.				
900	182·7	4·5	0	6·24
With Efflux.				
855	180·7	4	40	7·5

With the original Outlet opening, 12 in. deep.

No Efflux.				
900	182·3	4·15	0	7·35
With Efflux.				
885	180·7	4	40	8·25

No. 3, a.—With Inlet opening 24⅝ in. diam. Vane 11 in. long, by 10⅜ in. wide.

Number of Revolutions of Fan, per Minute.	Velocity of the Tips of Vanes in feet per Second.	Density of the Air, in ounces, per square inch.	Area of Discharge Pipe, in sq. inches.	Indicated Horse Power.
1000	224·5	5·8	0	6·1
1000	204 16	5·5	0	5 96
900	183·7	4·8	0	4·13
800	163·3	3 8	0	3·9
1000	204·1	5	31·8	7·3
1063·3	217 09	4	45	7
983 3	200·7	4	55	8·9
885	180·7	4	48·1	6 17
1100	224·5	3	63·7	8·7
966·6	196·6	3	70	7·29
870	177·6	3	82	7·8
786·6	160·5	3	65	6·76

No 3, b.—With the Outlet opening contracted to 3½ in. deep.

No Efflux.				
826·6	168·7	4	0	2·75
With Efflux.				
760	121·8	3·5	35	2·4

With the original Outlet opening, 12 in. deep.

No Efflux.				
813	166	4	0	3·46
With Efflux.				
813	166	3½	40	3·98

No. 4, a.—With Inlet opening 20⅛ in. diam. Vane 13⅜ in. long, by 10⅜ wide.

Number of Revolutions of Fan, per Minute.	Velocity of the Tips of Vanes in feet per Second.	Density of the Air, in ounces, per square inch.	Area of Discharge Pipe, in sq. inches	Indicated Horse Power.
1081·6	220·8	7·7	0	8·40
1000	204·16	6·7	0	7·84
900	183·7	5·5	0	5·2
786·6	160·5	4·4	0	4·45
1063 3	217·09	7	25	10·7
1063·3	217·09	6	42 5	11·47
966·6	196·68	6	35	10·07
966·6	196·68	5	65	14·04
878 5	179·15	5	37·5	7·3
983·3	200·7	4	79·6	12·7
870	177·6	4	66	9·9
773·3	157·8	4	35	5 7
870	177·6	3	103·6	10·7
786·6	160·5	3	97·1	10·42

No. 4, b.—With the Outlet opening contracted to 4 in. deep.

No Efflux.				
885	180·7	5·5	0	3·7
With Efflux.				
900	183·7	4	40	6·9

With the original Outlet opening, 12 in. deep.

No Efflux.				
885	180·7	5½	0	4·1
With Efflux.				
885	180 7	4	60 7	9 3

In the 14 inch blade, the tip has a velocity of 2·6 greater than the heel; or, by the laws of centrifugal force, the air will have 2·6 times the density at the tip of the blade that it has at the heel. The air cannot enter on the heel with more than atmospheric density, but in its passage along the vanes, it becomes compressed in proportion to its centrifugal force. The greater the length of vane, the greater will be the difference of the centrifugal force between the heel and the tip of the blade; consequently, the greater the density of the air.

Reasoning, then, from these experiments, I recommend for easy reference, the following proportions for the construction of the fan:—Let the width of the vanes be one-fourth of the diameter of the vanes.—Let the diameter of the inlet openings in the sides of the fan chest be one-half the diameter of the fan.—And, let the length of the vanes be one-fourth of the diameter of the fan.

In adopting this mode of construction, the area of the inlet openings in the sides of the fan chest, will be the same as the circumference of the heel of the blade, multiplied by its width; or the same area as the space described by the heel of the blade.

The following tables gives the sizes of fans varying from 3 to 6 feet diameter:—

TABLE 1.

Diameter of Fan. ft.	in.	Width of Vane. ft.	in.	Length of Vane. ft.	in.	Diameter of inlet opening. ft.	in.
3	0	0	9	0	9	1	6
3	6	0	10½	0	10½	1	9
4	0	1	0	1	0	2	0
4	6	1	1½	1	1½	2	3
5	0	1	3	1	3	2	6
6	0	1	6	1	6	3	0

TABLE 2.

3	0	0	7	1	0	1	0
3	6	0	8½	1	1½	1	3
4	0	0	9½	1	3½	1	6
4	6	0	10½	1	4½	1	9
5	0	1	0	1	6	2	0
6	0	1	2	1	10	2	4

I recommend the proportions in table 1, for densities ranging from 3 to 6 ounces per square inch, and for higher densities, viz.: from 6 to 9, or more ounces, the sizes given in table 2.

The dimensions of the above tables are not laid down as prescribed limits, but as approximations obtained from the best results in practice.

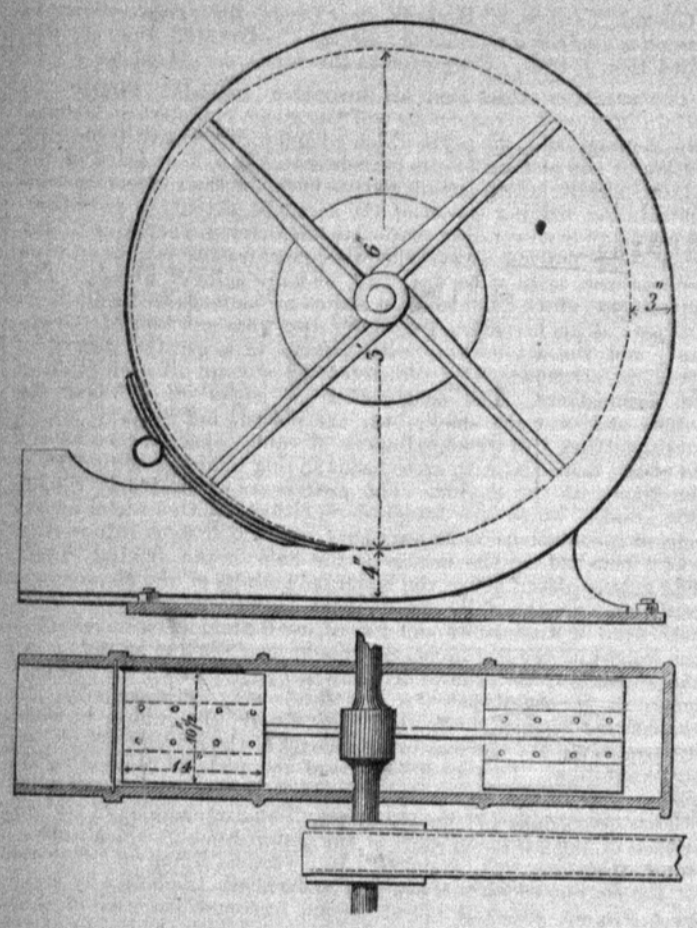
In some cases, two fans fixed on one spindle would be found preferable to one wide one, as by such arrangement, twice the area of inlet opening is obtained, compared with a single wide fan; and they may be so constructed, where occasionally only half the quantity of air is required, that one of them may be disengaged by a clutch, and thus a saving of power effected. In a single fan of great width, the inlet opening must either be made too small in proportion to the width of the vane, or if it be made large enough for the width of the vane, the length of the vane becomes so short as to be quite incapable of producing air of the required density.

It has been stated that the air from the fan chest is impelled by the vanes along the transit pipe, to the blast chest, &c.: I beg attention to the results of an experiment very recently made by me, with reference to the admission of air into the transit pipe, and which, I think, may lead to an important improvement in the fan. The experiment alluded to, was made to enable me to ascertain the result of varying the area of admission to the transit pipe, in proportion to the quantity of blast required for use; and I effected this by adapting a segmental slide to the circular chest of the fan, as shown in the accompanying section, by means of which, I vary the width of the opening into the transit pipe, from 12 to 4 inches.

The object of this arrangement is, to diminish the transit pipe opening at pleasure, in proportion to the quantity of air required, and thereby to lessen the power necessary to work the fan. The results will be seen by experiments inserted in tables 1 *b*, 2 *b*, 3 *b*, and 4 *b*. The inlet opening to the transit pipe having been contracted from 12 inches to 4 inches deep, so that the tip of the vane and the bottom of the outlet opening were nearly in a direct horizontal line, nearly the same quantity of air was impelled, as with the original opening; the noise produced by the fan had, however, nearly ceased. It therefore appears, that the less this opening is made—provided we produce sufficient blast—the less noise will proceed from the fan; and by making the top of this opening level with the tips of the vane, the column of air has little or no reaction on the vanes.

With respect to the degree of eccentricity which the fan should have, with reference to the fan chest, $\frac{1}{10}$ of the diameter of the fan

has been found in practice to answer well; that is, the space between the fan and the chest should increase, from $\frac{3}{32}$ of an inch at the top of the inlet to the transit pipe, to $\frac{1}{10}$ of the diameter of the fan at the bottom of a line perpendicular with the centre. The tunnel, or main pipe, from the fan chest may for short distances,



varying from 50 to 100 feet in length, be made not less than $1\frac{1}{4}$ times the area of the transit pipe in the fan chest; and in distances varying from 100 to 200 feet in length, $1\frac{1}{2}$ times the area of the transit pipe. The length of a tunnel may be continued to 300 or more feet, provided it be made of sufficient dimensions to allow the air to pass freely along it. The experiments accompanying this paper were made with a tunnel 18 inches diameter and 160 feet in length, and no difference could be detected in the density of the air, when the gage was applied at any part of the tunnel.

Having investigated the leading characteristics of the fan, it may not be out of place to give a few hints respecting its mechanical construction.

First.—It is one of the greatest essentials, that all parts maintain a just and proper balance.

Second.—That the arms of the fan be as light as is consistent with safety: round arms are decidedly objectionable; I have known instances when their centrifugal force has torn them from the centre boss. I prefer the rectangular arm, about the proportion of $2\frac{1}{2}$ times the width, for the depth at the centre, with sufficient taper towards the tips.

Third.—The bearings and journals of the fan spindle should be made of a length not less than four times the diameter of the necks of the spindle.

Finally.—The driving pulleys should be made as large as circumstances will admit of, so that the strap may have sufficient surface to prevent slipping.

The fan from which my experiments were collected, was made with these proportions. It has been at work nine years without any perceptible wear.

The application of the fan has hitherto been chiefly applied to smithies and foundries; and in but few instances has it been applied to the smelting of iron ore. I am aware that differences of opinion exist as to the applicability of the fan to that purpose. The principal reason urged against it being the limited density to which the blast can thereby be compressed, compared with the blast supplied by the cylinder. It remains, however, to be proved whether such high densities are absolutely necessary for the smelting of iron ore; whether we may not produce as good iron by a diffused soft blast, as by the strong, and generally applied, concentrated blast. I hope it will not be thought presumptuous on my part, in thus doubting long established practices. The old maxim of "there's no way like the old way," is not always based on unerring principles.

As I have before stated, the density of blast afforded by the fan, is limited to the force arising from the centrifugal motion of the air, in passing along the vanes of the fan; the quantity not exceeding what is due to its velocity and magnitude. But may not this density be increased by using a succession of fans, so constructed and arranged, that the air may be passed successively through each; the air from the first fan being made to enter the second, the air from the second to enter the third; and the blast finally emitted of adequate density?

I cannot here enter into a further investigation of this important subject; neither are the limits and character of this paper suited to the minutiæ connected with the principles and practice of a smelting furnace; but I hope that the observations which I have made, and the principles I have endeavoured to enunciate, will be the means of instituting further inquiry; and, as the expense of constructing a fan can be no barrier, I trust that a fair trial will be made, where convenience is suited to its application for smelting purposes.

REGISTER OF NEW PATENTS.

VENTILATION OF MINES.

JOHN WILCOCK, gentleman, in the county of York, for "*certain Improvements in the ventilation of mines.*"—Granted June 12; Enrolled Dec. 12, 1847. [Reported in the *Patent Journal.*]

The patentee, in this specification, states his invention to be for the purpose of improving, and more effectually securing, the better ventilation of mines, and consists of elongating the upcast shaft of the mine, by the addition of stacks, towers, or other similar buildings, erected above, or in connection with such upcast shaft, by which the upper orifice of the upcast shaft is elevated very considerably above the upper orifice of the downcast shaft, proportionably to various circumstances—as the relative depths of the two shafts, the velocity of the current of air through the mine, the nature of the gases, &c. The ventilation of mines is effected by the passing of a stream, or current, of atmospheric air through the various ramifications of the mine, carrying with it, in its course, the various noxious gases—as carburetted hydrogen, carbonic acid, and also the vitiated air, in its course, and escapes through the upcast shaft into the atmosphere. This current is, in most cases, caused—or the velocity of it is increased—by the application of heat to the upcast shaft, either at the bottom thereof, or at the orifice at the surface. The patentee proposes, by his invention, to increase the velocity of the currents through the upcast shaft, by erecting a stack, tower, or other similar building, above, or in connection with, the upcast shaft, which forms a continuation of the shaft, and through which also continues to flow the current of air. The height to which, in most cases, it will be sufficient to raise the elongated portion of the shaft, the patentee states to be from 60 feet to 100 feet, though this will be governed much by circumstances, varying in different mines. The patentee gives several drawings, descriptive of his invention, as applied to several descriptions of mine shafts; as, first, to its application to mines having only one shaft; in this case, it is customary to make partitions down the shaft, thus forming downcast and upcast shafts. The patentee proposes leaving these arrangements as usual, but erecting over, or in connection with, the part of the shaft, a stack, tower, or other building, as a continuation of the upcast shaft. Secondly, to a mine in which the upcast shaft is also the working one; in this case, the minerals and workmen pass out of the lower part of the stack, or tower, by an aperture in the wall of it; and, thirdly, to a mine in which the upcast shaft is only employed for that purpose; in this case, a plain stack, or tower, is employed. In all cases, the patentee states, it is necessary that the sectional area of the stack, or tower, should be, at least, equal to the sectional area of the upcast shaft; and that, when it is necessary to have any openings into the lower part of the stack, or tower, the sectional area of the upper part of the stack, or tower, above the

apertures, must be increased by the size of the apertures, for the purpose of not interfering with the upward current from the upcast shaft. The patentee, after describing his invention, claims the mode, or modes, of elongating the upcast shafts of mines, for the better ventilation of such mines, as described in the specification.

CONSTRUCTION OF BRIDGES.

Stephen Moulton, of Norfolk-street, Strand, Middlesex, gentleman, for "*Improvements in the construction of bridges.*"—Granted April 8; Enrolled Oct. 8, 1847.

The improvements are for constructing bridges in the manner shown in the annexed engravings. Fig. 1 is a side view of a bridge

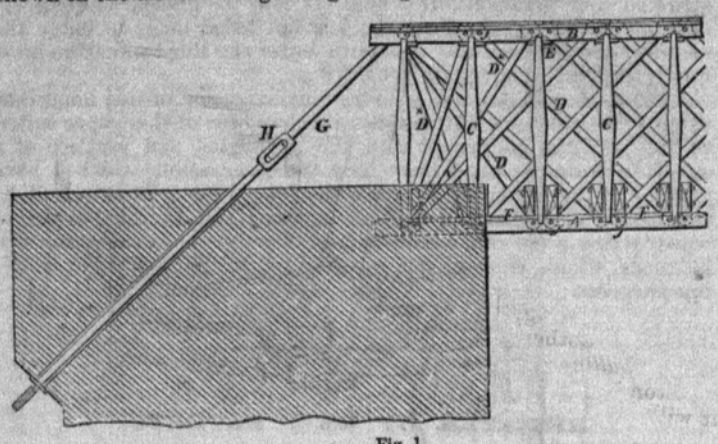


Fig. 1.

constructed according to the invention. Fig. 2 shows two transverse sections thereof, by which it will be seen that the top rail B, and the bottom rail A, are combined together by a series of diagonal bars D, so that the bottom rail A, is suspended from the upper rail B, by means of such diagonal bars D; and the rails, A and B, are kept apart by means of the uprights C, which uprights are not fixed to the upper or lower rails B, A, but simply come in between them as supports to retain the parts A, B, at the correct distance apart; and in the event of the chain being formed to act unequally on any of the diagonal bars D, by driving in wedges, as shown at E, fig. 1, the whole must be correctly adjusted. The diagonal bars D, proceed in opposite directions, and cross each other, as is shown, but they are not fixed to each other, they being simply fixed at their ends by means of pins passing through them; and the top and bottom rail, B, A, fig. 1, shows part of the side framing of the bridge.

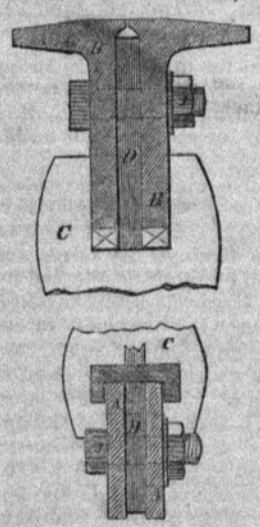


Fig. 2.

Fig. 3 shows the diagonal bars D, with the screw pins and nuts, by which they are attached to the rails A, B. The upper rail may be formed of two angle-irons, as shown at fig. 2, or in one double angle-iron, as shown at fig. 3, the diagonal bars D passing between the parts B B, and such parts will be held together by the pins and nuts J, as shown. The lower rail is composed of two bars, A, A, shown in fig. 2, and the ends of the bars D are placed between them, and held by the screw pins and nuts J, as shown. K, the beams for receiving the floor of the bridge. F, the caps which cover the upper edges of the two bars of which the bottom rail A, is composed. At the ends of a bridge it is preferred to use additional bars D*, D*, as shown at fig. 1, and also holding-bars G, with adjusting screws and nuts, as at H; but these may be dispensed with. There are opening through the uprights C, for the passage of the diagonal bars D, but these bars D should be free and not confined in the openings through such uprights C.

Fig. 3.

It will be found by examining the peculiar arrangement of the parts that great strength with lightness are obtained by constructing bridges in the manner described, for it will be evident that as the rails A, B, are kept separated by the uprights C, which act as stretchers, they will be rendered stiff and secure from flexure by the diagonal bars D.

LOCOMOTIVE ENGINES AND RAILWAY CARRIAGES.

George Taylor, of Holbeck, near Leeds, for "*Improvements in locomotive engines and railway carriages.*"—Granted June 3; Enrolled Dec. 3, 1847. [Reported in the *Mechanics' Magazine.*]

The patentee states that his invention consists: Firstly—In certain improved arrangements of the steam cylinders of locomotive engines, and the parts which communicate the reciprocating motion of the pistons of the cylinders to the axle or axles of the driving-wheels, which arrangements have for their object to concentrate the driving power of the actuated pistons, so as to communicate an even rotating motion to the driving-wheels, or to distribute the moving power (before concentrating it), in an even and uniform manner to one, two, or more pairs of wheels. The advantages which the patentee states he believes to result from this part of his invention are, diminished wear and tear of the engine, and the attainment, with safety, of a greater degree of speed, in consequence of the decreased amount of oscillation of the locomotives. The construction is as follows:—Above the boiler, and near the smoke-box, are placed, horizontally, and in juxta-position, two steam cylinders of equal capacity, each having its piston furnished with cross heads sliding in guides supported by the frame of the engine. The pistons are connected by rods to two cranks, which are attached on either side to a wheel having cogs or indentations on its periphery, and which gears into another wheel fastened on the centre of the axle of the driving-wheels. The axle is placed above the boiler, and allows of the employment of driving-wheels of larger diameter (say from 10 to 15 feet), with even a diminished amount of oscillation, in consequence of the weight of the engine being brought near the line of rails. All the wheels may be made to drive by being coupled in the ordinary manner. In order that the cog-wheels may work properly, and the bearing-springs of the engine act freely, the guides, in which are supported the journals or axle-boxes of the driving-wheels, are made slanting. Two modifications of the mode of connecting the piston-rods of the steam cylinders with the axles of the driving-wheels are specified by the patentee. The first consists in forming a slot in the centre of each of the piston-rods, in which works a short vibrating link, connected to a vertical frame on either side of the engine, which is made fast underneath the boiler by means of a pin, on which it vibrates—and in connecting each of these vibrating vertical frames by rods as is usual with the bosses of the driving-wheels, or in attaching one end of a connecting-rod to the outside end of the cross head of the piston-rod, and the other to the boss of the driving-wheel. Secondly—This invention has reference to the construction of an apparatus applicable to the locomotive, tender, and carriages, which serves to retard the progress of the train when necessary, and to support, in the case of the breakage of an axle, the weight of the carriage. To effect this, two levers are made fast to the bottom of the carriage in such manner as to allow of their acting freely, and have each at the outer end a flanged skid placed directly over the line of rail. These skids have on the under surfaces blocks of hard wood with the grain placed vertically, and are moreover connected by a strong spring. From the centre of this spring rises a vertical shaft, consisting of two pieces joined by a threaded connection, whereby it can be lengthened or shortened, as required. The top of this shaft is forked, and has between the prongs at top and bottom two anti-friction rollers; between these rollers is a cam, fastened to a horizontal rod, which is made to rotate by apparatus brought under the control of the driver or guards, after any ordinary and well-known means. When the longest radius of the cam is brought to bear upon the lower anti-friction roller by means of the rotating of the horizontal shaft, it follows that the vertical shaft is forced downwards and the flanged skids thereby depressed on to the line of rail which they bite, and thus retard the progress of the train. The flanges serve to retain the carriages on the line of rails, and the skids to support the carriage in the case of the breakage of an axle; but, in order that the vertical shaft may be relieved from the weight of the carriage, stops are inserted in the lower part thereof at the most convenient point, against which the skids catch. Thirdly—The patentee proposes to divide the tender horizontally into two parts, using the upper or open portion for coals, and the lower to contain the water, and to pass the axle of the wheels through the water or above it, in order that the weight

of the tender, as in the case of the locomotive before described, may be brought nearer the rails. Fourthly—To employ axles for railway carriages composed of two pieces, one solid and the other tubular, to slide over it; one of a pair of wheels being attached to each piece, so that they may revolve independently of each other.

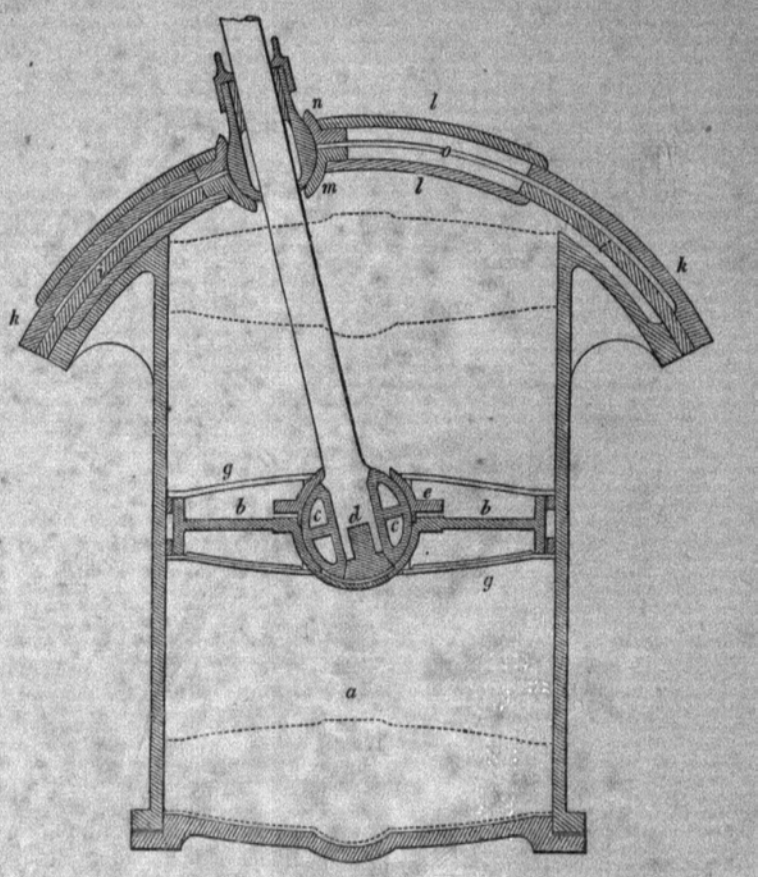
VIBRATING PISTON-ROD ENGINE.

G. V. GUSTAFSSON, of 15, William-street, Regent's-park, late engineer, R.N. "*Improvements in the steam engine.*"

The improvements relate, first, to "the mode of connecting a piston-rod to a piston by means of a ball-and-socket joint." The advantage of this plan over the old one (where the piston-rod is connected to the piston by means of straps and keys like the crank and connecting-rod) will easily be perceived; a *large* bearing surface, its facility for adapting itself in the centre of the piston, being bored and turned at the same time, and also the convenience for holding a lubricating substance, such as oil or tallow, and thereby lessening the friction, and causing a less wear of the ball and socket. Secondly, "The manner of keeping the piston tight within the cylinder by the combined mechanical forces of steam and metallic springs." The advantage of this arrangement will also be perceived without difficulty: the skeleton of the piston is formed like a wheel; the nave receives the end of the piston-rod, from which proceeds the arms, to the extreme ends of which a ring is attached, and to which ring is bolted the top and bottom cover of the piston, which for lightness should be made of wrought-iron; within these covers, and at the outer periphery, are fitted two metallic rings of light construction, and kept in their places by means of spiral and horizontal springs, but not necessarily steam-tight, as that will be effected by admitting steam into the chamber, which incloses the packing-rings by means of a double acting valve; this will cause a more *uniform* pressure on the packing-rings than could be effected by springs alone; it also requires very little fitting and grinding, only the side of the ring nearest the cover: it has also another, though perhaps not very great advantage, of partially *pulling*, instead of entirely *pushing* the piston. Suppose the piston is moving upwards, a portion of the pressure from under it will be removed to the upper cover, which is considerably above the centre of the globe; hence the pulling property, which in such case is preferable to pushing: the same, of course, takes place on the down stroke. Thirdly, "The construction of a moveable apparatus to be adapted to the top or cover of the cylinder through which the piston-rod is to slide, and at the same time vibrate." The advantage of this apparatus over the old slide-rest shaped one is, first, being *curved* as to present nearly a *rectangular* base to the different positions of the piston-rod, whereby the friction is considerably diminished; secondly, having a *flat* bearing surface to act against, instead of the dovetailed edges in the old plan; thirdly, and last, its facility of keeping in contact with the bearing surface, which is effected in condensing engines by connecting the narrow chamber, between the two slides, with the condenser, whereby the slides are kept in their places by the pressure of steam and the atmosphere: in non-condensing engines this chamber should be in communication with the atmosphere, which may be effected by causing the upper slide to bear in the middle *only*, allowing a passage to the chamber under it, which will also lessen the friction of the upper slide: it will be perceived that the slides are portions of circles, and consequently easy of construction. And fourthly, "An apparatus (or self-acting damper) for regulating the draught of the flues and furnaces, and thereby tempering the pressure of steam in the boiler, and also giving such due notice of the state of pressure in the boiler as may prevent accidental explosion." This being a distinct apparatus, may be used with or without the other improvements, and is applicable both for land and marine engines.

The inventor states that, "a plan, somewhat similar in principle, though differing in details, was tried many years ago, but in consequence of the ill-adaptation of the slides—somewhat like the *slide-rest* of a turning-lathe—to the motion of the piston-rod, being at *right* angles to the latter *only* at the dead points of the engine, or top-and-bottom stroke, it was a very great defect."

The three first improvements are shown in the annexed engraving of a vertical section of the steam cylinder. *a*, the cylinder; *b*, the skeleton of the piston, formed like a wheel for the purpose of rendering it of light construction; *c*, a hollow cast-iron globe, fitted to the end of the piston-rod and secured to it by a plug *d*, or it may be cast on to the end of the piston-rod: in the centre of the piston is a hemispherical socket, into which the globe *c* is fitted and secured to it by means of a cap *e* firmly bolted to the hemispherical socket; the arms have strengthening flanges on their under sides, and to the outer ring, at the extremity of the arms, is bolted the top and bottom covers *g g*, which, for lightness, may be made of wrought-iron. To render the piston steam-tight, two



metallic rings are placed in the annular chamber between the covers *g g*, and held in their places by means of vertical and horizontal springs, but not necessarily steam-tight, as that will be effected by admitting steam into this annular chamber of the piston by means of a double-acting valve, by which a more uniform pressure on the packing-rings is obtained than could possibly be effected by springs alone: *i* is the cylinder cover, which is made spherical, with segmental pieces to complete the arc of a circle; *k* is a segment slightly hollowed in the middle and bolted to the cylinder-cover; *l* are slides attached to the cups *m n*. To keep the radius slides *l l* constantly in contact with their bearing surface, the hollow space *o* should be in communication with the condenser, which is effected by fixing a small tube in any convenient place: in non-condensing engines this space should be in communication with the atmosphere.

It will be seen that as the piston ascends and descends, the piston-rod will be enabled, by the lateral motion of the radius slides, to vibrate, and thereby act directly on the crank; in consequence of the angular position of the piston-rod the wear of the cylinder would be greater on one side than the other, but this may be avoided by giving to the latter an inclined position. It will be perceived that this peculiarity of the piston is of great advantage, especially for horizontal engines, as the *weight* of the piston would be supported by the pressure, and consequently prevent an unequalizing wear of the cylinder and piston, which in common horizontal engines cannot be avoided; hence the vibrating piston-rod is particularly adapted for the screw-propeller and locomotive engines. To prevent an unnecessary waste of steam, the space between the piston and the cylinder cover, where the former is on the top stroke, as shown by the dotted lines, may be filled up with hard wood and bolted to the cylinder cover.

PALMER'S IMPROVEMENTS IN GAS.

PLATE II.

Fig 1

Fig 2

Fig 3

Fig 4

Fig 5

Fig 6

Fig 7

Fig 8

Fig 9.

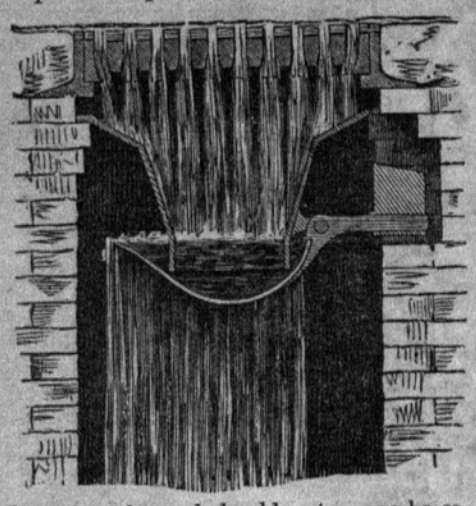
Fig 10

Fig 11

CB

BUNNETT'S SEWER TRAP.

Mr. Bunnett, of the firm of Bunnett and Corpe, of Lombard-street, has invented a very simple and cheap "*Self-acting Effluvia Trap*," which differs from all previous contrivances. The fault of the old invention was that they were so arranged that a very small quantity of water caused the pan of the trap to fall, and consequently during a shower of rain, or water falling upon it, the action was intermittent, continually opening a communication with the sewer, and liable to be held open permanently by any light matter being caught by the rising of the pan. In Mr. Bunnett's improved trap this is avoided by introducing a peculiar mechanical arrangement of the leverage connected with the form of the moveable pan, and application of the weight, which admits, under ordinary circumstances, of a constant flow of water through the grating into the pan of the trap and over the edge of the same into the sewer or drain, the lower part of the trap being immersed into the water, so as to form a most effectual water sealed joint, of sufficient depth to withstand the effects of evaporation from long drought, and should a stoppage be caused by a deposit of silt or other matter, the water will rise in the body of the trap, until it is about two-thirds full, at which point it raises the balance-weight, and obtains considerable leverage by the peculiar formation of the moveable pan, insuring a rapid discharge of a large body of water, which by its force most effectually cleanses the trap, and flushes the sewer or drain, and instantly recovers its position, with sufficient water to form the joint again, resuming its former action till another stoppage occurs; the form of the trap also insures on the commencement of a thaw the ready ejection of any ice that may have formed therein. The annexed figure is a sectio nal view of a street grating and gully hole with the trap, which is represented in its ordinary position, the water flowing from the grating into the body of it, and over the edges of the moveable part into the sewer or drain. The lower part of the body of the trap is immersed in the water which is retained in the moveable part by the counterbalance weight, thereby forming a perfectly sealed joint and effectually preventing any smell from rising.



Another advantage attending this trap is that it can easily be fixed to any gully hole, and the price is very moderate, being about £1 each.

GAS IMPROVEMENTS.

(With Engravings, Plate II.*)*

George Holworthy Palmer, of Westbourne-villas, Harrow-road, Middlesex, civil engineer, for "*an improved method or mode of producing inflammable gases of greater purity and higher illuminating power, &c.*"—Granted April 17; Enrolled October 17, 1847.

The first part of this invention relates to an improved mode of setting and arranging the retorts in conjunction with additional vessels called "regenerators," so as to insure their being heated uniformly to the required temperature (as shown in figs. 1 to 6), by which method not only an increase of volume, but also an increase in the illuminating power of the gas is obtained. The heating surface of the regenerators may be further increased by the introduction of metallic chippings, or by sheet iron partitions.

By this arrangement, the gas passes direct from the retorts into the regenerators, where it receives a second dose of caloric, and then flows in the usual manner through the sealed pipes in the hydraulic main, and then into the mechanical precipitator, to be next explained. The patentee recommends the retorts to be kept at a bright cherry-red heat, and the regenerators at a dull-red heat, visible by daylight.

The second improvement relates to an apparatus called a "mechanical precipitator," combined with a refrigerator (as shown in figs. 7 and 8), for the purpose of abstracting the vapours of tar and naphtha, as well as the gaseous ammonia and its compounds.

The third improvement relates to apparatus called "ammoniacal filtering towers," through which the gas passes from the precipitator, being washed in its course by liquid ammonia, descending like rain through one or more perforated plates, as shown in Nos. 1, 2, and 3, in figs. 9, 10, and 11. By this process a further portion of ammonia, contained in the gas, is absorbed without subjecting the gas to an increased pressure, and the liquid ammonia is increased in strength.

The fourth improvement relates to an apparatus consisting of a series of steam chambers and condensers, Nos. 4, 5, and 6, as shown in figs. 9 and 10, through which the gas passes from the filtering tower; each of these chambers is to be charged with a volume of pure steam equal to the volume of gas. The crude gas, with a volume of steam, passes first into No. 1 steam chamber, and then into its condensing chamber, where the steam will be condensed into water, which in its descent will carry with it a great portion of the remaining gaseous ammonia and its various compounds; after which, the permanent gases flow from No. 1 condenser into No. 2 steam chamber, when the gas will be again saturated with steam, and will again flow into its proper refrigerator, to deposit the steam charged with another portion of the product in a liquid form. The gas will then pass into No. 3 chamber as before, and thence into No. 3 condenser, where is deposited the remaining ammonia and its compounds, together with a portion of sulphuretted hydrogen. All these liquid products are to be made to flow, as fast as they are deposited in the condenser, into a suitable receiver, sealed by an hydraulic joint to prevent the gaseous vapours and gas from returning into the condenser. From this last apparatus the gas will pass, freed from impurities, into the "lime machines" or purifiers, charged with dry lime, where it is divested of the remaining deleterious gases—viz., sulphuretted hydrogen and carbonic acid, and proceeds thence to the gas holder, and lastly to the mains.

The gas now purified goes into the gas-holder, and, in its transit to the mains, may be naphthalised if required; for this purpose, apparatus may be employed similar to that described as the "ammoniacal filtering towers."

The fifth improvement is for avoiding the inconveniences which arise on opening the purifiers and removing the refuse lime from the sieves preparatory to recharging them with lime, and which is to be effected by causing atmospheric air, heated or otherwise, to be blown through the material employed for purifying the gas, and discharged through the furnace-bars or chimney-shaft, by means of a "centrifugal bellows" or other suitable pneumatic apparatus, the blast-pipe being connected to the exit pipe of the purifier; thus blowing out the contaminated air, &c., through the pipe by which the gas enters the purifying vessel, an extra pipe and valve being attached to the entrance and exit pipes for this purpose.

Reference to the Engravings.

Figs. 1 to 6 show the mode of setting and heating the retorts and regenerators: fig. 1, a sectional elevation, and fig. 2, a front elevation —each figure shows one-half of a set of retorts; fig. 3, a longitudinal section; fig. 4, a plan of one of the retorts, showing the opening through which the flame rises; fig. 5, sectional plan of the top retort; and fig. 6, sectional plan of the regenerators.—Similar letters refer to similar parts:—*a*, *b*, *c*, retorts; *d*, *e*, *f*, regenerators, showing the plates *k* to increase the heating medium, over which the gas flows from the retorts; *g*, *g*, the furnaces; *h*, *i*, flues through which the flame rises from the furnaces, and, as indicated by the arrows between and over the retorts and regenerators, to the shaft, and *l*, the blow-holes. There is one regenerator to each retort, of the capacity of about two-thirds the latter.

Fig. 7 is a vertical section of the "mechanical precipitator," and fig. 8, plan of the same; *a*, *a*, perforated revolving fans, to agitate the gas in the chamber *b*, *b*,—the shaft is stepped into the lower chamber and passed through an inclined plane, *d*, *d*, under which the gas blows through the tar passing from the pipe *x*; and adjoining is a chamber, *e*, containing a convoluted worm, or refrigerating pipe, *g*, to cool the gas after escaping from the chamber *b*, through the curved pipe *f*. To prevent the gas blowing through the aperture in the inclined plane where the shaft passes, the shaft is inserted in a pipe *z*, bolted to the inclined plane, being of an altitude sufficient to overcome the pressure of the gas; and instead of the usual stuffing-box for the shaft, an hydraulic seal *t*, is used.

The pipe is kept cool by a supply of water passing through the chamber *e*, by the pipe *h*, entering at the top and discharging by the pipe *j*. The pipes *h* and *j*, together with the chamber *e*, form a syphon; the legs or pipes, *h* and *j*, are furnished with cocks *p*, to admit or cut off the supply of water. An air-pump is used to remove the small quantity of air that may be in the syphon; it *is*

worked, as well as the agitating apparatus, by the descent of water flowing from the long leg of the syphon, which gives motion to a small water-wheel in connection with the bevel wheel, gearing, and band; or they may be worked by a steam engine or other power. All the condensable products collected in the agitating chamber and refrigerating pipe *g*, flow through the pipe *n*, into the chamber *c*, and through the opening *r*, at the level of the dotted line, into a receiver.

Fig. 9 is a plan, and fig. 10 a sectional elevation, of the "ammoniacal filtering towers," steam chambers, and condensers, combined in one apparatus. The gas takes the course indicated by the arrows in the towers 1, 2, and 3, entering each at the bottom and out at the top, and thence into the steam chambers 4, 5, 6, undergoing the steaming and condensing before explained; *a*, *a*, steam pipes, with cocks to regulate the steam; *b*, the entrance steam pipe from the boiler; *c*, *c*, *c*, separate condensers, with the entrance and exit pipes; *d*, the tank for the ammoniacal liquor, pumped up through the pipe *e*; the tank has two divisional plates *f*, *f*, fixed to the top and sides, and descending to within a few inches of the bottom of the tank, and is sealed at the level of the dotted line by the liquid ammonia.

To insure the gas flowing from one tower to the other, each has a pipe, *g*, connected with the tank and rising in it to the height of the dotted line, at which level the ammonia flows through the pipe *g*, into its particular tower.

Instead of the arrangement of the filtering towers, several perforated divisional plates, *n*, as shown in fig. 11, may be adopted, the gas flowing from the tower into the chamber through the pipe *w*, in order finally to escape at the pipe *y*.

REVIEWS.

An Essay on the Air-pump and Atmospheric Railway; containing formulæ and rules for calculating the various quantities contained in Mr. R. Stephenson's report on atmospheric propulsion, for the Directors of the Chester and Holyhead Railway Company. By WILLIAM TURNBULL, author of a treatise "On the Strength of Cast-Iron," &c. London: Williams. 1847. 12mo. pp. 96.

The object of this excellent little treatise is a general exposition of the theoretical principles of atmospheric railways. That the leakage of the main tubes of these railways involves a loss of power, is obvious to every one in the slightest degree acquainted with the subject; but it requires much more than superficial knowledge to estimate the precise amount of loss corresponding to a given rate of leakage. Mr. Turnbull has addressed himself very successfully to the task of substituting exact principles for general notions respecting the mechanical defects of atmospheric propulsion.

The first part of this work comprises a history of the air-pump, and demonstrations of several known formulæ by which its effects are estimated. In the second part, these formulæ are applied in detail to the case of the Kingstown and Dalkey Railway. Notwithstanding the imperfect success of the method of substituting stationary air-pumps for locomotive engines, the subject is one of permanent interest to the engineer, on account of the number of beautiful scientific and mechanical problems which it presents to his attention. Considered merely as an instructive exercise, the theory of atmospheric propulsion deserves to be thoroughly mastered by every student of practical science. It is this consideration which induces us to give a brief sketch of Mr. Turnbull's method of investigation.

When a train on the atmospheric railway has attained its uniform velocity, it is obvious that, if there were no leakage, the pump-piston and the train-piston must both describe the same space in a given time—that is, the void made by the one in a given time must be filled up by the other. For example, if the relative diameters of the main tube and pump were such, that ten feet of the length of the former had the same cubic capacity as one foot of the length of the latter, the train-piston would travel ten feet while the pump-piston travelled one. Otherwise, if the pump-piston travelled at a greater relative velocity, the degree of vacuum would be raised, and the train accelerated; if the pump-piston travelled at a smaller relative velocity, the degree of vacuum would be diminished, and the train retarded: and either case is contrary to the hypothesis of uniform velocity of the train.

The exact relation, however, between the uniform velocities of the two pistons only obtains on the hypothesis that there is no leakage. The principal problem is to ascertain the modification due to that defect of the apparatus. The requisite data for this investigation are obtained by the following experiment:—After the tube has been exhausted to a certain extent, the whole apparatus is suffered to remain quiescent, no train being dispatched. The leakage will then go on till the equilibrium of the air inside and outside tube be restored. By observing the rate at which the barometer-guage falls during the interval, we get—not the rate of leakage—but data from which that rate may be calculated.

The density of air is proportional to the weight, and therefore height, of the column of mercury. Take 30 inches as the height of mercury corresponding to the atmospheric pressure; then, if the barometer-guage of the exhausted tube show, for the pressure in it, a height equivalent to 10 inches of mercury (for example), the density in the tube would be to that of the external air as 10 : 30, or would be $\frac{1}{3}$rd the ordinary density of air. If, after the leakage has gone on some time, the barometer-guage show a height equivalent to 20 inches for the pressure in the tube, the density will be $\frac{20}{30}$, or $\frac{2}{3}$rds that of common air. The *difference* between the densities in the tube at the two respective periods is $\frac{2}{3}$rds $-\frac{1}{3}$rd $(=\frac{1}{3}$rd$)$ that of common air. Consequently, if the quantity of air which has entered the tube in the interval, be supposed to have diffused itself equably throughout the tube, that quantity is equivalent to the tube full of air at a density $\frac{1}{3}$rd that of common air, or, which is obviously the same thing, one-third the tube full of common air. This reasoning applies generally, and gives this simple rule—that the cubic quantity of air admitted by leakage during any interval, is equal to the cubic capacity of the tube multiplied by the fraction expressing the difference of densities during that interval. (The barometer-guage is so graduated, that for the words, "fraction expressing the difference of densities" in the above rule, we may substitute, "difference of gauge-heights divided by 30.")

If this quantity of air were divided by the number of minutes of the interval, the result would be the rate of influx per minute, supposing that rate uniform. This method of investigation is, however, liable to an objection, which our author well states as follows:—

"We have calculated for the extreme indications of the vacuum gauge, and divided by the number of minutes that elapsed during the observation, for the average leakage per minute. Now this method would be perfectly just, on the supposition that the quantity of leakage is constant, or of the same amount in equal times; but the idea of a constant amount of leakage is altogether incompatible with what we know to take place, when air of atmospheric density is allowed to flow into a vessel containing air of a less density. Here it is obvious that the air in the vessel is continually approaching to a state of equilibrium with that without, and consequently the velocity of influx is continually diminishing until the equilibrium obtains."

He then proceeds to show, that in those experiments on the connecting pipe of the Dalkey line, in which the heights of the gauge were taken every minute, though the successive differences of those heights for successive minutes were nearly equal, they do not indicate a uniform rate of leakage, but lead to the directly opposite conclusion, that the leakage was far more rapid at the beginning of the experiment than at its conclusion: and he then makes the following important remark in reference to Mr. Stephenson's report:—"*We are somewhat apprehensive that, by assuming a constant amount of leakage for the connecting pipe, some very erroneous deductions must have been made.*"

"But with regard to the valve tube the case is very different; for it is easy to conceive that, as the longitudinal slot or aperture is covered with a flexible substance, this substance will readily accommodate itself to the pressure as the exhaustion goes on, and by thus diminishing the area of the aperture as the velocity of influx increases, a constant amount of leakage, or nearly so, may happen to be maintained: at all events, it is not inconsistent with the maxims of accurate science, to admit that such may be the case, and it actually appears from experiment that the supposition is not far from the truth."

If it be conceded that the leakage of the connecting pipe is an avoidable evil, and may therefore be assumed to be wholly remedied, we have very simple means of calculating the effect which the leakage of the main tube has on the velocity of the train. As the assumption of uniform leakage in this tube is somewhat dangerous, let the leakage corresponding to any proposed working vacuum be ascertained by a separate experiment with the barometer-gauge. We have explained how to calculate, from the fall of the gauge, the quantity of external air which enters the tube per minute. It may be calculated by very simple arithmetic what length of tube this quantity of air would by *itself* occupy, if dilated to the supposed working density. And that length of tube is the measure of the loss of speed of the train during the minute; for

if there had been no leakage, the train-piston would have advanced that length further during the minute.

This is a brief and imperfect sketch of Mr. Turnbull's system. We must observe, however, that the results will agree only approximately with actual practice. The fundamental hypothesis of uniform velocity of the train, is not unobjectionable: it is true that in calculating the motion of locomotive engines, the hypothesis will lead to results of specific value; but, on atmospheric railways, the distances performed with accelerated or retarded speed must bear so large a proportion to those performed with uniform speed, that the latter can hardly be considered the normal condition. There are other reasons for concluding that calculations of the motion of trains on atmospheric railways cannot be exact. However, the partial application of sound theoretical principles to practical subjects, of which a perfect theory is unattainable, is a most important advantage. The skilful research exhibited in Mr. Turnbull's treatise, is the more welcome for being applied to a subject which has, in a pre-eminent degree, suffered the martyrdom of parliamentary and newspaper philosophy.

A Guide to the Proper Regulation of Buildings in Towns as a means of Promoting and Securing the Health, Comfort, and Safety of the Inhabitants. By Wm. Hosking, Architect and C.E. London: Murray, 1848.

This work of Mr. Hosking evidently contains so much practical and useful matter that we do not like to dismiss it with a passing notice, but we intend to devote a little time to its consideration. Meanwhile, whatever opinion we may entertain with regard to some of its recommendations, we have seen quite enough of it to feel justified in recommending it to our professional readers.

Earthwork Tables. By C. K. Sibley and W. Rutherford.

The authors have published an appendix to these very useful tables, showing how the tables may be applied to *side-lying* ground, for which they give the following rule:—"Ascertain the ratio of the area of cross sections of the side-lying ground to the areas of similar cross sections, that is with same height on centre line, of level-lying ground, and multiply by that *ratio* the complete quantity furnished by the tables."

The Antiquarian and Genealogist's Companion. By William Downing Bruce, Esq., F.R.S.L. & E.

This is a novelty for the antiquarian student, which will be very favourably received at the present season, as it contains many curious memoranda and an archæological calendar for the year. The work is small—which may, perhaps, be an additional recommendation.

LECTURES ON GEOLOGY.

By Professor Ansted. Delivered at King's College, London.

On the Application of Geology to Engineering and Architecture, and the Supply of Water to Towns and Cities.

Professor Ansted commenced his fifth lecture, by considering the question of drainage, more particularly with reference to general engineering, which depended, in many cases, very distinctly on the geological structure of the rocks. And it did so naturally, as, for instance, in an ordinary road, properly made, where the drainage would ultimately have reference to the structure of the material and to the rocks in the neighbourhood. With regard to geological structure, it might happen that the beds which came close to the surface would have a strong inclination; and, in that case, where the beds were permeable, the road would be drained naturally, and, where one part lay on an impermeable bed, and the other on a material which suffered the water to percolate through it, an attention to geological structure would enable them to carry off all the water very satisfactorily. This would illustrate the applicability of geological knowledge, even to common road making; but that knowledge was still more directly available in the case of railroads, which, running through a long extent of country, involved the necessity of frequent and deep cuttings, in the execution of which drainage, as connected with structure and geological considerations, must always come in. Suppose, then, they were to take a transverse section of a railway cutting, similar to one of the diagrams exhibited—if the beds were horizontal, the two sides would be situated in a similar manner with regard to accidents arising from unequal pressure; but if that were not the case, and the bank was composed of mud, clay, sand, or any slippery earth, in beds inclined to the horizon, some parts of the superincumbent mass would be more apt to slip down than others. Some strata would carry water, and others would allow it to drain through; and if the road did not go directly on the strike, in which case there was no inclination as far as the purposes of the road were concerned, there would be a greater tendency to "slip" on the one side than on the other. Supposing the uppermost beds were composed of some heavy material resting upon a bed of sand, the rain, in draining through the sand, would wash it away gradually, and, a portion of the support being removed, the upper mass would naturally have a tendency to slide down upon the lower part. If once it began to slide, no matter how slowly—if the movement were only an inch per day, or an inch per month—any preventive measures were too late, and there would be a slip sooner or later, and especially in heavy rains, or rains combined with frost. But before the superincumbent mass were set in motion, if by any means the water could be prevented from passing through the sand, it might be prevented. That was best done by cutting a drain on the other side, by which all the water which came on the surface might be carried off before it reached the sand. There would then be sufficient cohesion to prevent the upper part from being set in motion.

A knowledge of geological structure, in making these cuttings, was exceedingly useful, not only in preventing slips, but in reducing the cost of work. For instance, when the dip was in a certain direction, a slip was manifestly impossible, and in that case the slope of the bank might be very much steeper, and the expense of its removal saved. On the continent, it was not unusual in cuttings to make the banks in a succession of terraces; but, in this country, that plan, though exceedingly useful, was scarcely ever adopted. It was, however, being partially tried at New Cross, a place where much mischief had been done by slips, and he believed with a prospect of success. That was, however, a plan which could not be carried out without a reference to geological science.

On the subject of *embankments* the same principles of drainage were applicable, though another element of construction was brought into action. If a large mass of material were heaped in a particular way, it might be perfectly safe, and answer the purpose intended very well; while if it were placed in a different way, mischief would arise. The structure of embankments ought also to be regulated by the nature of the rocks on which they rested, as well as those of which they were formed; and although, as yet, few accidents had arisen, engineers might find it worth while to pay attention to this subject. Again, if an embankment was placed on a hill side, there ought to be particular adaptation to the way in which the beds lay. If a heavy pressure were put upon beds so situated, which had already a tendency to slip, that tendency would be increased, and, unless attention were paid to the drainage, serious accidents would inevitably occur. The kind of draining required was much of the character of that necessary in ordinary roads—namely, by cutting off springs which had a tendency to run between bands of impermeable rock.

The subject of *canals*, and the way in which they were affected, introduced another element. In making canals, the engineer would constantly have to cut across springs, and through some strata which allowed water to percolate, and through others which actually produced water. In going across a district where there was much leakage, it was necessary to have a perfect knowledge of the nature of those rocks which yielded water and abounded in springs; and of those strata and substances which were impermeable. On such circumstances depended many great practical difficulties in the construction of canals. It was a remarkable fact, that Mr. William Smith, who flourished about a century ago, and who was called the father of English geology, was himself a mining engineer, and first observed the geological structure of the country, as it affected the formation of canals. His life, lately published by Professor Phillips, his (the lecturer's) predecessor at King's College, would be found very useful and interesting, as it regarded the practical application of so much of geological science as was known at that day. In the life of Smith would be found some account of the construction of canals in his day, then as important as railways were now. They would see how he brought his knowledge to bear upon the problems at issue, and in that way they might themselves learn how to apply a great deal of that knowledge of geology which they might possess.

Supply of Water.—The Professor next treated of the supply of water as an engineering subject, apart from the supply obtained from land-springs, or small Artesian wells, considered hitherto on a comparatively small scale, and rather with relation to agricultural purposes than engineering. The subject of drainage and water supply was, perhaps, connected as much with architecture as engineering; but, when he had discussed its relations to the one, it would scarcely be necessary to touch upon the other.

With respect to the supply of water, the Professor thought he could not do better than give them a short outline of what had been done lately with regard to the large and most important town of Liverpool, which had been noted, for some time, as a place which was badly supplied with water, and had been more remarkable than any other town in England, for the prevalence of fevers, the more than average illness of its inhabitants, and the short duration of life in the major part of it. The members of the corporation appeared very anxious to do all in their power to remedy that which was certainly one source of those evils—namely, the deficiency in the supply of water. Accordingly, they resolved to obtain an Act of Parliament, empowering them to adopt some measure, which should give the town a larger quantity of that important element. The town was situated on the new

sandstone, and had hitherto been supplied from wells sunk into that stratum, which consisted of a red sand rock, sometimes very soft, sometimes rather hard, intersected with occasional bands of marl, very much faulted with large and continuous veins, often filled up with clay, and many of them completely impermeable. The new red sandstone rested upon coal measures, and certainly contained a great deal of water, which was absorbed from the immediate surface, or drained into it from the hills in pretty large quantities, of which the actual limits were ascertainable, since they knew how much fell from the clouds, and how much was evaporated; and they could calculate how much was lost by drainage into the rivers. The supply thus obtained was found to be very insufficient for the necessities of the town, and it was supposed that the quantity could not be materially increased from this source. This point, however, had to be decided upon by reference to the structure of the district, and by calculating whether they got all the available water of the district, or only a part, and it turned out that the latter was the fact. The mode in which this water was obtained was by wells, with horizontal galleries at their bottoms, to allow the admission of a large quantity of water, which was then pumped to the surface. The water obtained from the new red sandstone contained oxide of iron and some salts of lime and magnesia, which made it exceedingly hard, and ill adapted economically for many useful purposes connected with the manufactures of that neighbourhood, and in all operations in which soap was required. It was very good to drink, but unfit for other domestic purposes. The question was, whether a sufficient supply, even of this water, could be obtained from the district? The proprietors of the wells attempted to show that an increased quantity could not be obtained. It was to their interest that that should be the case, and they very naturally believed that it was so—consequently. they opposed all measures, the object of which was to obtain water from any other source. The corporation gathered all the information that could be obtained locally, and then called upon several scientific men for their opinion; and it is a fact of great interest, as illustrating the present practical position of geology, that it was thought necessary to have the opinion of persons, more noted for their geological knowledge than for simply a practical acquaintance with engineering. Professor Phillips was first invited to give his attention to the subject, but was prevented from doing so by his engagements with the Government. He (Professor Ansted) was then applied to, and after close examination and full consideration, he came to the conclusion that a sufficient supply could not be obtained from the new red sandstone formation, he being of opinion that, though a somewhat larger quantity might be had of the water which fell on the district, yet that would not be nearly enough for the requirements present and prospective of a town like Liverpool. What was next to be done? Then came in that admixture of engineering with geological science, now necessary indeed to every engineer, who wished to do his work satisfactorily, and with the consciousness that, whatever the result, every means had been adopted which the circumstances of the case would allow. The engineers looked about the neighbourhood far and near, their object being to discover where the necessary supply was to be found. One scheme, which met with considerable favour at first, was to take the water from the Bala Lake, in North Wales, and convey it to Liverpool, a distance of 60 miles, by closed canals. Great natural obstacles, however, intervened, and it was found that this plan involved an enormous expense, with the chance of incurring still greater outlay in overcoming several of those natural obstacles, which could not be well estimated until the work was attempted. This scheme, after exciting much discussion. was at length abandoned, and the engineers began to look nearer home. After again considering the supply from the wells, and again convincing themselves of its utter inefficiency, they found they must resort to other means, and thus originated the somewhat celebrated Rivington Pike scheme. The Rivington Pike district presented a hilly surface of 17 square miles, admirably adapted by nature for such a project. The plan pursued in this case was to take the district and measure its area of drainage, then to estimate the quantity of water that could be obtained from it, and, finally, to consider how the water might be best accumulated. This was a beautifully scientific problem, perfectly practical indeed; but one which had rarely, if ever before, been tried to the extent now proposed. First of all, they had to see whether the quantity of water would be sufficient; and this was effected by accurately marking the water shed, observing where all the rills and streams could be caught conveniently, and, when caught, considering whether they could be conducted into some sound and sufficient reservoir. The model on the table, which was an accurate representation of the district, would show that all those points were readily attainable. The drainage was regulated by the shape of the country, and it might be seen either by the Ordnance Map, a contour map, or a model. In this case, he was able to exhibit a model, which was the best; but the Ordnance Map was the guide originally used. Having then found the area, the question whether it would yield a sufficient quantity of water to supply the town of Liverpool was next to be decided. This calculation involved a considerable amount of knowledge of geological structure. It was easy to tell how many inches of rain descended from the sky on a certain space and in a given time; and they had only to multiply that by the whole area intended to be drained, and they would have the exact quantity which fell upon the whole. That was simple enough; but they had then to ascertain what was the nature of the surface on which the water alighted; for if it were permeable, as sand, for instance, it was obvious that a large proportion would be absorbed and lost; or, if there were many hollows, the water would lie in them and evaporate. These and other geological considerations had all to be well considered; but geological science showed that the district, being composed of the bed of hard sandstone, called millstone grit, partially covered over with shaley beds belonging to the coal measures, the whole of it might, for practical purposes, be regarded as impermeable. The sandstone rock, oftentimes very soft, was here very hard, a good deal faulted but not open—so that it would allow almost the whole of the water to run off the surface. The consequence was, that almost all the rain that fell ran into the streams, which a further examination showed might be readily collected into two principal reservoirs on the side of the district nearest to Liverpool, which would be 24 miles distant. The natural valleys, in which it was intended to place these reservoirs, had, no doubt, held water before, as the bottoms were covered with fresh water silt. There were also beds of alluvial clay—an additional indication that a considerable quantity of fresh water had at some period been there. By means of two or three embankments, these lower districts would thus accumulate that water, which the structure of the upper districts allowed to run off. The whole of the rain which falls upon an area of 47 square miles would thus be collected, producing a supply of 20,000,000 gallons per day, sufficient for the town of Liverpool were it twice the size, and also for the supply of a more useful and economical article to the mills, bleach-works, and other works in the neighbourhood. Here advantage was taken of the peculiar natural circumstances of the district, to make the *minimum* quantity of surface produce the *maximum* amount of water; but which could never have been accomplished, but for a distinct geological knowledge of the structure of the district. Had it not been for a practical application of geological science, that on a certain description of stone the whole of the water would run off, the selection of the Rivington Pike district would never have been made, and the probability was, that Liverpool would have remained for a much longer period suffering from the want of a sufficiency of so vital a fluid. This was a remarkable instance, in which a knowledge of structure had been applied to superficial objects of this kind.

The Professor dismissed the subject of draining by explaining the nature of the operation of a newly-invented draining pipe (Watson's draining pipe), which was remarkably effective. It was cylindrical, with a great number of longitudinal slits, which were wider inside than outside, and thus counteracted any tendency to clog. These pipes were most useful to insert in beds of clay, and, even after a considerable length of dry weather, might be seen giving out water very plentifully. This efficient draining caused the beds to contract and crack, and, by thus making openings for the water, rendered the draining perfect. To the proper use of these pipes a knowledge of the dip of the beds was indispensable.

The next subject was connected with *materials as required for various engineering operations, and used for a vast number of economical purposes.* These he would divide in the same manner as he had divided the various rocks, and he should commence with the clays.

Clay was either mixed with limestone or with sand, in various proportions, and was a very important material. All clays contained alumina, but a considerable number of materials existed, some known by the name of clays, and others, though belonging to the class, not recognised by the general appellation. Of clay, properly so called, there were several distinct kinds. One was the clay found in the shape of subsoil, chiefly used for agricultural purposes. In this case it consisted, not only of silicate of alumina, the base of all clays, but of limestone, magnesia, potash, iron, &c., and was none the worse for a little phosphorus; while it contained also a quantity of carbon. This admixture was indispensable for vegetation; but for "materials" clays were better without these foreign substances. The most common clay considered as a material was known by the name of *brick clay;* it was a silicate of alumina, with a certain amount of free sand in very variable quantities, which might, however, be easily determined by washing. A good brick clay should consist solely of these materials, without lime or potash, and if the free sand was not in sufficient quantities, it must be mixed with it to make it work; and, generally speaking, the purest, in the common sense of the word, was the best for making bricks. The clay derived from the decomposition of some of the old rocks was particularly valuable, and that derived from the decomposition of slate was generally most pure, and was useful, in certain districts, in the manufacture of *fire-bricks.* The best kinds were the purest, and contained neither alkanes nor salts, either of which make it run, in the great heat to which it was subjected in the furnaces. The presence of such substances helped the action of the fire, and the surface of the brick would be turned to glass. Pure clay and sand was thus the best for fire-bricks, and it was obtained, as he had observed, from slate. The London clay, one of the tertiary series, was for the most part tolerably well adapted for bricks—indeed, all London was built of it; but it was not well suited for the making of fire-bricks, though it possessed many separate portions that were so. The mischievous ingredients might indeed be separated, but generally it was not worth the trouble and expense, as there was no great difficulty in obtaining clay for fire bricks.

Pipe-clay or *potters'-clay*, another of this class, was used in the manufacture of the rougher kinds of earthenware. This was a most useful material, and did not require to be so carefully selected as that used for fine pottery and porcelain. It contained a considerable quantity of water, and it was unctious and soapy to the feel. It was necessary for the purposes of the potter that it should contain a considerable quantity of water, which usually amounted to 18 per cent. It did not contain sand; but it usually had about 1 per cent. of oxide of iron, and a small quantity of lime. The chemical composition of materials of this kind, however, was not very accurately ascertained, as they were for the most part accidental mixtures, and were apt

to vary in different localities. Pipe-clay was obtained from beds situated in the midst of other clays, and they appeared to form a band of finer material associated with the coarser clays. There was a great deal of this clay found at Paris, where it was called *argile plastique*. The lower beds of the London clay were also described as *plastic clay;* but they consisted, for the most part, of gravel or pebble beds, for which that was not at all a proper name. Still, some of them contained this material.

Fullers' earth was another and a finer kind of clay, used in the fulling of cloth, on account of its power of absorbing grease readily from woollens. It contained an unusually large quantity of silica, as compared with the ordinary pipe-clay, the proportion of the latter being 43 per cent. of silica, and 33 of alumina; while that of the former was—silica, 53; alumina, 10; the other parts being made up of iron (about 9¾ per cent.), magnesia (1 per cent.), and water (24 per cent.). Fullers' earth was derived from the Weald clay at Nutfield, in the neighbourhood of Reigate, and from the lower part of the oolite rocks in Wiltshire. In each case there was a considerable variation in the colour, occasioned by the condition of the oxide of iron; but the texture was the same, and the colour was a matter of very little consequence.

Porcelain clay was another important material. This was derived from decomposed felspar, obtained generally from gneiss, or granite. It was the purest of all the clay rocks, being a pure silicate of alumina, consisting of 60 per cent. of silica, and 40 of alumina. A large quantity (8,000 tons annually) of the finer kinds was obtained in Cornwall by artificial washing. Besides this, upwards of 25,000 tons of the coarser kinds was obtained from beds formed by the natural washing of the rains. The decomposed felspar was mixed with water in the artificial process, and moved along at a certain velocity, when the whole was gradually deposited in the shape of porcelain clay. The coarser parts were deposited first, when the mass moved most rapidly; next, the finer parts, as the mass moved slower; and, lastly, the finest of all.

There were other clays worthy of notice, as, for instance, the *ochres*, red and yellow, the colour being decided by the condition of the oxide of iron, which was present in them in considerable quantities. These, however, were not important as materials.

From some clays, the substance called *alum* was derived; but that, like the ochres, was not an important material, geologically speaking, although interesting from the chemical process by which it was obtained. The talented lecturer concluded by briefly describing this process.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Nov. 29.—A. Poynter, Esq., V.P., in the Chair.

The Secretary read the Report of the Committee appointed to examine the design submitted by the Cavalier Nicolò Matas for the completion of the western front of the Cathedral at Florence. The report expressed in general terms an approval of the design; and stated that the architect has shown judgment in adopting the style of the other parts of the exterior—thus seeking to complete the noble edifice in one congruous character, in harmony with the Campanile and the Baptistery. By this unity of sentiment, the design for the western front appears a consistent and integral part of the structure.

A paper was read by J. Gwilt, Esq., entitled, "*Some discursive Remarks on Pointed Architecture, in relation to its Symmetry and Stability.*"

The essay was of considerable length, and traced in a general way the origin of Gothic architecture. Mr. Gwilt stated that of a great number of writers on that subject whom he had consulted, he found that twenty were of opinion that it originated in Germany, fourteen that it was of Eastern or Saracenic origin, six that it arose from the hint suggested by the intersection of Norman arches, four that it was the invention of the Goths, and three that it arose in Italy. Mr. Gwilt was of opinion, with M. Michelet ("Histoire de France"), that when the power of the Church diminished about the year 1200 under Innocent III. the arts, particularly architecture, fell into lay hands to a considerable extent; that the impetus thus given changed its character; and that in the hands of the lodges of Freemasons which then arose Gothic architecture and all its developments were originated and taught. By the aid of diagrams and drawings the gradual growth of the fine forms of Gothic architecture were developed and its principles explained; the leading fact seeming to be that the number of sides in the polygonal apsides of the cathedrals was the governing number for all the parts of the plan and even the details of the architecture. Many curious instances of these analogies were given. Mr. Gwilt combatted the "Vesica Piscis" theory, as well as the vagaries, as he called them, of the symbolists.

A communication was read from E. I'anson, relative to some mural paintings discovered by him in the church of Lingfield, in Surrey. These paintings, fac-similes of which were exhibited by him, represented draped figures, about three feet in height, on a diaper groundwork, and appeared to have been executed in distemper. They had at some period been covered over with whitewash; on which the Commandments and scriptural texts had been inscribed.

Dec. 13.—S. Angell, Esq., V.P., in the Chair.

A paper was read "*On the Principles and Practice of Building Sewers.*" By E. I'anson, jun., Fellow.

The intention of the author was to show that sewers might be effectually constructed with a moderate fall; that no one form of section is applicable under all circumstances, but that no form should materially depart from that of the semicircular invert; that all main sewers should be of sufficient altitude to allow a man to pass through; that no impediment should be offered to the continuous flow by cross streams or accumulating deposits; and that cleansing by "flushing" is an efficient means of removing the silt and other matters in the sewers. Mr. I'anson particularly alluded to the necessity of all sewers being of sufficient, but not of more than sufficient, sectional area to contain the greatest quantity of water that may at one time have to pass off—or that, as in the case of districts below the level of high water, they may have at one time to contain. In reference to the idea of constructing sewers of small size and removing the contents by continued pumping, Mr. I'anson remarked, that as the pumping power should be at all times equal not only to discharge the average quantity of water, but also that of the greatest quantity which may at any time be required to be passed off, it was obvious that there would be an enormous continued waste of power at a cost more than commensurate to the saving effected by constructing the sewers of smaller size.

SOCIETY OF ARTS, LONDON.

Nov. 10.—Thomas Webster, Esq., F.R.S., in the Chair.

The Secretary read an address on the opening of this the 94th Session of the Society.

Mr. J. Cundall read a paper "*On Ornamental Art as applied to Ancient and Modern Bookbinding.*"

The author commenced by stating that the earliest records of bookbinding prove that the art has been practised for nearly 2,000 years; previous to which time, books were written on scrolls of parchment. Some inventive genius, however, to whom the Athenians erected a statue, at length found out a means of binding books with glue: the rolls of vellum, &c., were cut into sheets of two and four leaves, and were then stitched somewhat as at the present day. Then came the necessity for a covering. The first book-covers appear to have been made of wood, probably merely plain oaken boards, which were afterwards succeeded by valuable carved oak bindings; these were followed by boards covered with vellum or leather, and specimens of such of great antiquity still exist. The Romans carried the art of bookbinding to considerable perfection, and some of their public officers had books called "Diptycks," in which their acts were written. An old writer says that about the Christian era, the books of the Romans were covered with red, yellow, green, and purple leather, and decorated with silver and gold. In the 13th century some of the gospels, missals, and other service books for the use of the Greek and Roman churches, were covered in gold and silver; some were also enamelled and enriched with precious stones and pearls of great value. In the 15th century, when art was universal, such men as Albert Durer, Raffaelle, and Guillo Romano, decorated books. The use of calf and morocco binding seems to have followed the introduction of printing, and there are many printed books bound in calf with oaken boards about the 15th and beginning of the sixteenth centuries; these are mostly stamped with gold and bhud tools: the earliest of these tools generally represent figures, such as Christ, St. Paul, coats of arms, &c., according to the contents of the book. In the reign of Henry VIII., about 1538, Grafton, the printer, undertook to print the Great Bible, for which purpose he went to Paris, there not being sufficient men or types in England; he had not, however, proceeded far when he was stopped in the progress of this "heretical book," upon which he returned to England, bringing with him presses, type, printers, and bookbinders, and finished the work in 1539. Henry VIII. had many books bound in velvet, with gold bosses and ornaments; and in his reign the stamping of tools in gold appears to have been introduced. In the reign of Elizabeth, some exquisite bindings were done by embroidery, the queen herself working the covers with gold and silver thread, spangles, &c. Count Grolier seems to have been a great patron of the art on the continent, and all his books were bound in smooth morocco or calf ornamented with gold. The style of the books of Maioli was very similar to that of Grolier, or those of Diana of Poictiers, the specimens done for her being among the finest ever produced, and were no doubt designed by Petit Bernard. Rogar Paine was the first Englishman who produced a really good binding, and some of his best works, such as French romances, were powdered with the fleur-de-lis. His books on chivalry had suitable ornaments; on poetical works he used a simple lyre, and carried the emblematical style of binding as far as emblems ought to be used. The following bill of his for binding a work is a curiosity, and shows how moderately he charged:—

"Vaneria prodium Rusticum, Parisiis, MDCCLXXIV.

"Bound in the very best manner in the finest green morocco, the back lined with red morocco. Fine drawing-paper and very neat morocco joints inside. Their was a few leaves staind at the foredge, which is washed and cleaned	0	0	6

"The subject of the book being 'Rusticum,' I have ventured to putt the Vine Wreath on it, I hope I have not bound it in too rich a manner for the book. It takes up a great deal of time do these Vine wreaths; I guess within time I am certain of measuring and working the different and various small tools required to fill up the Vine wreath, that it takes very near 3 days' work in finishing the two sides only of the book—but I wished to do my best for the work, and at the same time I cannot expect to charge a full and proper price for the work; and hope that the price will not only be found reasonable but cheap .. .. 0 18 0"

Of the binders of the present century, the following deserve to be mentioned with respect—viz., Mr. Mackenzie, Mr. Clarke, Mr. Bedford, and Mr. Hayday; the bindings by the latter consist almost invariably of adaptations and modifications of ancient examples. Among the many splendid specimens of his work exhibited, that of "the Sheriffs of Shropshire," in imperial folio, deserves special notice, as being enriched with the armorial bearings beautifully coloured. The binding is of blood-coloured morocco, extending an inch and a half all round the inside of the cover, on which is stamped a bold, open border, tooled in gold.

The author, after alluding to the numerous specimens of modern bindings which have of late been produced to the public, and regretting their want of originality, concluded by urging the necessity of attempting something original and suitable to the advancing and improving taste of the time. Then we may hope that ere long ornamental art in bookbinding will be wedded to our present perfect execution, and that the 19th century will be able, like the 15th, to boast of a style of its own.

Mr. H. COLE, assistant keeper of the Public Records, exhibited a number of very curious and beautiful specimens of bookbinding, among which was one containing the deeds relating to Henry the Seventh's Chapel at Westminster, in which the monks undertake to pray for the soul of its founder as long as the world is.

Nov. 17.—W. H. BODKIN, Esq., V.P. in the Chair.

The first communication read was by Mr. BRIANT, on his "*Plan for overcoming the difficulties of a Break of Gauge, and of Uniting the Broad and Narrow Gauge Railways.*"

Mr. BRIANT commenced his paper by pointing out the difficulties which had arisen from the adoption of the two gauges in this country, and the objections which have been urged against the various plans—viz., the telescopic axles for the wheels; the shifting of the carriages from one gauge on to that of another; laying down double lines of rails; &c. He then proceeded to describe his own plan, which is as follows:—At the point of junction of the two gauges, a platform is to be fixed in the centre of the rails; the carriages are then to be placed upon wheels, the two ends of the axles of which are to be made as male screws; on the centre of the axle a pinion-wheel is to be fixed, and under it attached to the frame of the carriage a lever, upon the upper side of which is a rack, and at the lower end an anti-friction roller. The nave of the wheels is to extend under the carriage in the form of a female screw, to receive the axles. By this arrangement, while the train is travelling on the narrow gauge, the wheels would be screwed up to the required width, the racked lever hanging loosely under the pinion-wheel, and the axle would turn with the wheels; but when the train reached the point of junction, the lever would be caught up by the platform (which is to be 40 yards long), and with it the rack. The axle would thus be prevented from turning by the pinion-wheel and rack, and the wheels, from the weight of carriage, passengers, luggage, &c. pressing upon them, would immediately begin to unwind the screws, which, by the time the carriage has reached the other end of the platform, will have extended the axle to the required width—the lever would drop and free the pinion-wheel, and the axle would then turn with the wheels as before. The wheels are kept in their position when unwound by coupling-rods. In backing the train, the screw is prevented from acting by means of a stop fixed to the carriage and blocking the axle. A working model was exhibited.

The second paper read was by D. J. HOARE, Esq., "*On a Railway Telegraph and Alarum, to be used as a means of Communicating between the Guard and Driver of Railway Carriages.*"

The plan proposed is that a series of rods should be passed through the carriages of a train, and united at their extremities by a telescope-joint, so as to allow of extension and contraction: the rods being made with a universal joint, admit of a rotary motion,—the only motion which a railway train has not. At the end of the rod on the guard's carriage is a crank, which, when the rod is turned, comes in contact with a hammer, and causes it to strike a bell. A signal is then to be raised, indicating the carriage from which the signal is made; the guard will then immediately ascertain whether it is necessary that the train should be stopped, and if so, by turning the rod in the reverse direction to what the person signalling had done, will ring another bell at the driver's end of the train, or sound the whistle of the engine.—Mr. Hoare stated that it is immaterial what the curve of the railway may be, as the universal joint admits of the rod varying from a right line. It would also act in case a carriage got off the line, or even on to the buffers of the carriage preceding it.

Nov. 24.—T. WEBSTER, Esq., F.R.S., V.P., in the Chair.

The first communication read was on Mr. DUTTON'S "*Railway Communicator.*"

Mr. DUTTON proposes that a small metal pipe should be fixed in some convenient part of each railway carriage, and connected at its extremities with the carriage preceding and following it by means of a short length of vulcanized india-rubber tubing and a kind of bayonet fastening; at the end of the tube, near to the guard's seat, a whistle is to be fixed, which will be capable of being sounded by the passengers on their blowing into a small branch tube, to be fixed in each carriage in connection with the metal pipe. A model was exhibited.

The second communication was by Mr. F. BROTHERS, "*On his plan for forming a Communication between the Passengers, Guards, and Drivers of a Railway Train.*"

Mr. BROTHERS proposes, by means of a fly-wheel, to be worked by the rapid current of air passing through it, to set in motion a multiplying power which shall work a small air-pump, and compress air into a chamber in connexion with which two whistles shall be fixed; one of these the passengers are to be capable of sounding, by allowing the compressed air to escape. The second whistle is to be of a different size and sound, and entirely under the control of the guard, and only to be used when it is necessary to stop the train.

The third paper was by Mr. E. E. ALLEN, on his means of effecting a similar communication.

Mr. ALLEN proposes to make use of electricity as a means of sounding the steam whistle. Galvanised wires are to be carried along each of the carriages of a train, and the electric circuit is to be completed by the use of galvanised coupling chains, which, so long as the circuit is complete, magnetises a piece of soft iron and holds a detent attached to the steam-cock; but whenever the circuit is broken, the iron is demagnetised, and the detent allowed to go free, upon which the steam escapes, and the whistle thereby sounded.

The fourth paper read was by Messrs. BRETT and LITTLE, on their method of forming a similar communication.—In this plan, as in Mr. Allen's, it is proposed to use an electric current, the circuit of which is to be completed by means of wires and chains, but is to act only when the circuit is complete, when a bell is rung.

Dec. 1.—W. WYON, Esq., R.A., in the Chair.

Five specimens of "*Painting on Glass,*" by M. DE RON, of MUNICH, were exhibited.—The Secretary stated that the colours used by M. De Ron are peculiar, and the method of preparing them known only to himself, and which colours are glasses of different degrees of hardness, care being taken in using them never to put a harder upon a softer metal. He also uses both sides of the glass, which enables him to obtain clearness and decision of colour.

Mr. HALL offered some remarks on the history of stained glass, and exhibited several specimens of modern manufacture.

Mr. S. MOULTON exhibited a model of an "*Iron Truss Railway Bridge,*" the invention of Mr. RIDER, of New York.—The peculiarities of this bridge are its simplicity, lightness, and strength. The directors of the New York and Harlem railroad have erected a bridge on this principle, the span being 70 feet, and having a double track or roadway upon it; the entire weight of metal used in its construction was 13 tons, while its cost was under £500.

A paper was read by Mr. ARCHER, "*on Engraving with reference to Monumental Brasses and Incised Stones.*"

The author commenced by referring to the very early period at which the art of engraving appears to have been known and practised by the lapidary and goldsmith, and the probability that those to whom the art was known were subject to a precise code of laws and connected with the priestly office, these laws having the effect of regulating the productions according to a given standard set up by the heads of their order; thus giving a singular uniformity to the numerous examples of antique art, whether in painting, sculpture, or engraving. After alluding to the Egyptian, Etruscan, Greek, and Roman specimens of engraving, and their similarity and common origin, he proceeded to point out the various purposes to which the art of engraving on brass was employed, such as the representation of geographical diagrams. In the time of Herodotus, edicts and public records were sometimes inscribed on brass tablets, a striking instance of which occurs in the preservation down to the present time of the will and acts of the emperor Augustus. Having touched upon some few instances of the ancient practice of the caleographic art, the author proceeded to detail some particulars of that process as it appeared at the general revival of art during the middle ages. In the 8th century, by a law of Kenneth, king of Scotland, it was enjoined that a cross should be put on every gravestone—*i. e.* coffin-lid; and this appears to have been done in three ways:—1st. By the use of incised lines drawn around the object. 2ndly. By producing the form in low relief. 3rdly. By a wholly excised figure.—The use of sepulchral brasses appears to have originated with the general revival of art in the 13th century, one of the earliest specimens being that of Sir Roger de Trompington, who died in 1289. The brasses of the 14th and 15th centuries contain, besides the effigies of warriors, churchmen, ladies, and civilians, many examples of beautiful decoration, derived from the architectural practice of the time. Different combinations of the letters I.H.S., composing the sacred monogram, appear in the brasses of the 15th and beginning of the 16th centuries. In the 16th century, at the time of the Reformation, these sacred monuments appear to have become obnoxious, and were accordingly swept out of the churches with an unsparing hand—few (comparatively) having escaped de-

struction: of some of these, however, the author produced rubbings; and, having traced the history down to the 19th century, and referred to the latest of that period (prior to those produced under his own direction), he proceeded to urge the desirableness of possessing as a nation a complete collection of the rubbings of the brasses of this country, as illustrative of the costume and history of bygone times, and the propriety of such a collection being deposited in the British Museum. The author then concluded his paper by calling attention to the cartoons of several monuments recently executed by himself, by a new processs of working on brass, and which he promised to communicate to the Society at an early period.

Dec. 8.—T. Hoblyn, Esq., in the Chair.

Mr. H. Cole made some remarks in reference to Mr. Archer's paper on sepulchral brasses and incised stones, read at the last meeting. He observed that about ten years since the study of brasses re-commenced in this country. During that period, however, almost all that is known respecting the brasses has been exhausted, and several works have been written on the subject; so that there is scarcely anything to find out, unless the brasses happen to lay under pews or in parts of the churches which at present are concealed. The most remarkable have been published by the Cambridge Camden Society, and on the walls are exhibited engravings from a book of great excellence by Waller: others have also paid attention to the subject. The ordinary process of obtaining rubbings is as follows:—A sheet of paper is laid upon the brass, and kept in its position by weights; it is then rubbed over with a composition known as heel-ball. By this means, the whole of the paper where the brass under it is not cut away becomes blackened, while the incised lines remain the colour of the paper. In some cases, a kind of bronze composition is used upon a black paper, and by this means as nearly as possible a facsimile of the brass is obtained. The most important brasses to be found in London are in Westminster Abbey, St. Helen's, Bishopsgate, Allhallows, and St. Andrew's Undershaft. Passing out of London, the nearest churches where any remarkable brasses are to be found are, Willesden, Harrow, South Minns, St. Alban's, Broxbourne, Cheshunt, Roystead, Chigwell, Windsor, Stoke-Pogis, Taplow, Westerham, Penshurst, and Cobham.

Mr. Hall made some remarks relative to the history of copper-plate engraving, and the probability that it grew out of the art of engraving monumental brasses.

Mr. Slocum exhibited two ploughs, a scythe and cradle for reaping corn, a grass scythe, three spring tempered manure and hay forks, a cast-steel hand hoe, and an American axe. He stated the peculiarity of these implements to consist in their lightness, cheapness, and durability, thus enabling the agricultural labourer to accomplish a larger amount of daily work at a less cost. The implements he exhibited were such as are commonly used in the United States.—A letter was read from Mr. Love, of Manor House, Naseby, in which he states that the ploughs were tried on a clay soil, in rather a dry state, against Adams's Northampton plough, and one of Howard's Champion ploughs. Howard's, when working five inches deep by eleven inches wide, had a draught of 31 stone; and Adams's plough, at the same width and depth, a draught of 30 stone; while the American plough, at five inches deep and fourteen wide, drew only 26 stone. "In justice to the American ploughs, I must say," observes Mr. Love, "that they cut up and cleaned their furrow quite as well as the other ploughs, and also turned the earth, completely breaking it, and putting the soil in capital position for drilling or dibbling; they are the most simple, strong, light, and effective ploughs it is possible to conceive: other experiments were also made, and the draught tested by the dynamometer."—The cost of the ploughs Mr. Slocum stated to be £2 each.

A communication was read from Mr. W. Taylor, F.L.S., &c., "*on the Cultivation of the Polygonum Tinctorium, or Dyer's Tinctoria.*"

"This plant," observes Mr. Taylor, "is a native of China, and was introduced into this country in 1776, by John Blake. It is used in China and Japan for the purpose of dying a blue similar to that of the finest indigo. The colour is obtained from the leaves of the plant, which are dried, pounded, and made into cakes. 'With these cakes,' Hunberger says, 'they dye linen, silk, and cotton.' When the cakes are boiled, they add ashes; and the stronger the decoction is made, the darker is the colour. The plant grows best in this country on soils of a medium texture, which must also be well manured before the seed is sown, which is best sown in rows about the middle of April. Two pounds of seed to the acre is sufficient, but the plants may be planted out in rows from the hot bed, at the rate of about 16,000 to the acre; and unless they are brought forward and planted out, they will not produce seed in England. The plant can be prepared for the market in three ways, viz.—1st, it may be cut in a green state and sold to the dyer, in which case an acre would produce five tons of leaves and stalks, worth about £30.—2nd, if cut and placed in vats, so as to precipitate the fecula, or indigo, the acre would produce 3 cwt. of colour, which, at 1s. per lb., would be worth £16 16*s.*—3rd, the plants may be cut up, dried, and packed in bundles: the acre would then yield three tons of dyeing matter, and be worth about £21. The colouring matter may be extracted either by fermentation or scalding." Specimens of the plant and colour were exhibited.

The last communication read was by Mr. W. Bennett, "*on some samples of Flax grown in Ireland in* 1847."

Specimens of the flax were exhibited, and Mr. Bennett stated they were produced under every disadvantage possible, and in one of the most remote and destitute corners of the whole island, viz., the barony of Eoris, county of Mayo, on the western coast, and under the superintendence of Mr. G. S. Bourns, the peasantry being wholly unacquainted with its mode of culture and preparation. The flax is of good quality, and worth from 6*s.* to 8*s.* per stone. The introduction of its culture has also afforded employment to a large number of poor women in spinning. The peasantry are also being employed to manufacture linen from looms erected in the stables of a clergyman, in another most distressed locality, specimens of which were exhibited.

ROYAL SCOTTISH SOCIETY OF ARTS.

Nov. 8, 1847.—David Maclagan, M.D., F.R.S.E. President, in the Chair.

The following communications were made:—

1. *On the first principles of Symmetrical Beauty, as developed in the Geometric Harmony of the Human Head and Countenance.* By D. R. Hay, Esq.

Mr. Hay commenced his paper with a quotation from Dr. Reid's "Intellectual Powers of Man," showing that it was the opinion of that great philosopher, that, as taste might be true or false according as it was founded on true or false judgment, it must have first principles. He then observed, that by truth being properly investigated in the natural sciences, natural philosophy had arrived at its present advanced state, and its application in the useful arts had consequently produced the happiest results. But that in our search after truth in the science of æsthetics, a very different course had been followed, and that our ideas of beauty were clothed in mystery, and our attempts to produce the former in the various branches of art, depend in a great measure upon chance. This he attributed to the practice of servile copying in our schools of art, instead of studying the first principles or teachable laws of beauty; in short, that we study and imitate results without investigating causes. He asserted that there exist precise mathematical principles of a practical nature, by which the external form of the human head and countenance may be delineated, and by which the proportions and relative positions of the features may be arranged upon the facial surface so as to produce a primary species of symmetrical beauty; and that these principles were identical with those which produce beauty in architecture and ornamental design. This he demonstrated by combining in a diagram the Platonic triangles and the curvilineal figures that belong to them, showing, at the same time, that those triangles were the root of all symmetrical beauty and harmony in geometry. He showed that this diagram corresponded in all its parts to the anatomy of the human head, and that the countenance thereby produced possessed the *beau ideal* beauty of the finest Grecian sculptures. Mr. Hay stated that he believed the principles he explained were known to the ancient Greeks, and were introduced by Pythagoras, and taught by Plato in connection with mathematics, and by Pamphilus as connected with art. The drawings by which Mr. Hay exemplified his principle were larger than life, and very numerous, and we understand it is his intention to publish them on a small scale.

2. The Report of the Prize Committee, awarding the Prizes for Session 1846-7, was read.

Nov. 22.—G. Buchanan, Esq., President, in the Chair.

The following communications were made:—

1. *Suggestions for preventing Accidents on Railways.* By J. Stewart Hepburn, Esq., of Colquhalzie. These suggestions have reference to the injudicious practice of mixing light with heavy carriages in different parts of the train, and to the injudicious applications of the break, and the order in which it is applied; and propose the classification of the light and heavy carriages, and the working of the break from the rear to the front of the train. They have also reference to the permanent works of most railways as originally constructed, being too light and insufficient for the heavier loads and high velocities which are now used; and propose to give increased stability to the rail by a well laid pavement of heavy blocks of stone, along the outside of each rail. They have also reference to what is called "jumping," which is often the cause of carriages running off the line—to unequal subsidence of the roadway, and proposes Telford's plan for forming the embankments in concave layers, or that the earthworks should be allowed ample time to subside of themselves before the rail is used. Mr. Hepburn also proposes longitudinal supports under the joinings of the rails, which he considers their weakest part. The suggestions have also reference to the entanglement of the buffers, and "riding" on each other; and propose to enlarge vertically the surface of the buffer, by having in its place three elliptic springs on the lower frame of the carriage, and two on the upper part, each set connected with a horizontal bar of wood, and the whole covered with boarding. Mr. H. holds that this arrangement would prevent the carriage from turning up and rolling over each other when a collision takes place.

2. *Description of a Model of a Malleable Iron Railway Chair.* By Mr. Robb, Haddington. The advantages are stated to be greater strength, and thus giving additional security in passing sharp curves: the rails would fit much better from the chairs being all cut true to the pattern, thus securing a uniform bearing to the head of the rails: the superior manner in which the wooden keys will fit, and with less rigidity. Mr. Robb thinks they could be made cheaper than cast-iron chairs, and that they would be stronger, although one-half lighter, whereby a saving in cost of carriage would be effected to an extent of 50 per cent.

3. *Description of a proposed Improvement in Railway Switches.* By Mr. NICOLL, Arbroath. These switches are placed on iron chairs so constructed as to move along with the switch, whereby the motion of the switch is not prevented by its getting jammed with dust or rubbish; and the chairs, from their peculiar form, push aside the dust and clear a way for the switch. Mr. Nicoll also gives a description of the apparatus for opening and closing the switch, so as to prevent accidents by the motion of them by unauthorised persons.

4. *A Railway Alarum Communicator.* By Mr. MOFFAT. The object is accomplished by a tube sunk in the roof of each carriage, and to connect these are tubes of India rubber with screws. Inside the tube is a wire, and attached to it inside of each compartment of the carriage are bell-pulls or knobs. At each guard's seat are bells and knockers, and the same at the driver's, fixed near the engine. A passenger wishing to give a signal, pulls the knob, by which means the whole bells are rung. The tube can also act as a speaking-trumpet, mouth-pieces being inserted in each compartment, and the same to the guards and drivers—so that a passenger having rung the bell, communicates to the guard and driver, &c., his reason for so doing.

5. *Description and Drawing of an Alarum Rein for Railway Trains.* By Mr. M'COLL. The rein is attached to a whistle valve on the engine, and extends along the whole train on the locked side; so that any person, by pulling the rein, opens the whistle, and informs the driver that something is wrong.

Dec. 13.—G. BUCHANAN, Esq., F.R.S.E., President, in the Chair.

The following communications were made:—

1. *Description of the Overarch Suspension Bridge.* By Mr. MILNE. This bridge is so constructed that the roadway runs under the arch, and is connected to it by suspending rods, which are so disposed that a large portion of the arch sustains a small portion of the roadway, thus enabling the bridge to bear a concentration of weight at any point. The main rods of the arch lean against each other at the centre (where the key-stone of a stone bridge is situated), giving mutual support, which is continued towards each end of the arch by circular extenders, enlarging as they approach the piers. The pressure of the main rods against each other is thus turned to the utmost advantage, and gives the greatest stability possible; and from this construction the lee-side will resist a gale of wind with the full power of the arch. The model is twenty inches in length, on the scale of ten feet to an inch. The entire weight of iron is six ounces, and it safely bears a load of 56lb.—nearly 150 times its own weight.

2. *Supplementary Explanations of an improved Railway Break.* By J. STEWART HEPBURN, Esq. This is an improvement of break submitted by the inventor to the Society last session. It consisted of a rubber block of wood attached to railway carriages by a moveable frame-work; and applied, not to the wheel, like the common break, but to the rail, by a gradual pressure capable of being increased to such a degree, on an emergency of danger, as to raise the hind wheels from the rail.

3. *Improvements in Railways.* By Mr. JOHN CRANE. The first improvement is for locomotive engines to ascend or descend steep inclines. It consists in laying along the incline a toothed rail, outside of the common rail, and keying on additional wheels with teeth on the shaft of the driving wheels of the engine, outside of the bearing wheels, and working in the toothed rails, and the teeth of which are to work in the teeth of the rail; thus pulling on the train.—The second improvement consists in making the wheels with double flanges, one on the outside of the rails, as well as the usual one within them. Thus the wheels would be less liable to go off the rails.—The third improvement consists in laying the rails on longitudinal sleepers, connected together by cross sleepers, and forming a series of strong square frames.—The fourth improvement is for a break. Instead of pressing against the wheels, and thereby retarding them by friction, and eventually locking them, the break falls down at once between the wheel and the rail, inserting itself between them like a wedge, and thereby locks the wheels, and, at the same time, rubs upon the rail. Four wedges are required for ordinary carriages, one pair at each end; each pair of wedges is connected by a bar of wrought-iron, in the centre of which a chain is fastened, which can be raised by the guard, and fastened by passing one of the links over a hook. When the chain is detached from the hook or button, the break, by its own weight, and guided by a rod attachad to the carriage, falls under the wheels and prevents them revolving. The guiding rod to have its centre of motion eccentric to that of the wheel, and that centre to be a pin fixed on the axle frame of the carriage, a little above it, so that the wedges when raised may be clear of the wheels.

NOTES OF THE MONTH.

Railway Precautions.—Mr. Wyndham Harding, in a letter to the Institution of Mechanical Engineers, recommends, as the most simple and best method of forming a communication between the guards and engine-drivers, "That the guards should have the means of readily getting along every train, whether a passenger or a goods train, to the engineman. This (he observes) was the original idea in narrow-gauge trains, for the means are afforded of getting from one carriage to another, but the idea has been imperfectly carried out, inasmuch as a horse-box or a luggage van afford no facilities for getting past them. Nothing is easier than to remedy this by holdfasts and a narrow foothold. In the case of flat trucks loaded with such goods as cotton, uprights at the four corners, and a rope from one upright to the other, would afford a hold for the guard, and would also, at the same time, tend to steady the load. In the vehicles which travel in passenger trains even such an addition as this would not be necessary. On the broad-gauge lines connected with the Great Western Railway, there is generally no facility afforded for getting along the train, but such facilities can with equal ease be afforded in broad-gauge trains as on narrow by trifling additions to the vehicles." Mr. Harding caused additions with this object to be made to the broad-gauge carriages on the Bristol and Gloucester Railway when he had the control of that line.

Commissions of Sewers.—The old commissions for Westminster, Holborn and Finsbury, Tower Hamlets, and for the Kent and Surrey districts, were all in one week superseded, and a new commission, consisting of the following, were nominated for *all* the districts, on the 6th ult.:—Lord Ebrington, Lord Ashley, Dr. Buckland, Mr. Hume, M.P., Hon. F. Byng, Dr. Arnott, Dr. S. Smith, Mr. R. A. Slaney, M.P., Sir J. Clark, Rev. W. Stone, Professor Owen, Sir H. De La Beche, Mr. J. Bidwell, Mr. J. Bullar, Mr. W. J. Broderip, Mr. R. L. Jones, Mr. J. Leslie, and Mr. E. Chadwick.—Mr. L. C. Hertslet, Clerk of the Westminster division, and Mr. Staples, Clerk of the Holborn and Finsbury division, were appointed clerks of those districts provisionally; and Messrs. Phillips and Roe were appointed surveyors provisionally, and Mr. Austin consulting-surveyor.

Brussels Lace.—M. Blanchet gave an account of the serious consequences resulting from the process of whitening Brussels lace to the persons employed in it. In this process the carbonate of lead is used; and a large portion of it is carried into the atmosphere, where it is inhaled, and thus produces a serious affection of the intestines. It is also very injurious to the sight and to the hearing.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM NOVEMBER 30, TO DECEMBER 22, 1847.

Six Months allowed for Enrolment, unless otherwise expressed.

William Betts and George William Jacob, of Wharf-road, City-road, for "Improvements in the manufacture of capsules, and in the application of certain descriptions of surfaces."—Sealed Nov. 30.

William Eaton, of Camberwell, engineer, for "Improvements in machinery for twisting cotton or other fibrous substances."—Dec. 1.

Gustavus Moenck, of Wellington-street, Strand, D.LL., for "certain Improvements in clocks and time-keepers."—Dec. 1.

Thomas Chandler, of Stockton, Wiltshire, for "Improvements in machinery for applying liquid manure."—Dec. 1.

Frederick William Mowbray, of Leicester, paper dealer, for "Improvements in machinery for the manufacture of looped fabrics."—Dec. 1.

Samuel Newington, of Frant, Sussex, M.D., for "Improvements in dibbling or sowing seeds."—Sealed Dec. 7.

John Scoffern, of Upper Holloway, M.B., for "Improvements in the manufacture and refining of sugar."—Dec. 7.

John Britten, of Birmingham, machinist, for "certain Improvements in apparatus for cooking, preparing, and containing human food and drinks, and in opening and closing oven doors, parts of which improvements are applicable to other similar purposes."—Dec. 7.

James Smith Torrop, of Edinburgh, newspaper proprietor, for "Improved machinery for time signals."—Dec. 7.

William Dakin, of 1, St. Paul's Church-yard, for "Improvements in cleaning and washing coffee, in the apparatus and machinery to be used therein, and also in the apparatus for making infusions and decoctions of coffee." (Communication.)—Dec. 7.

James Sweetman Elffe, Esq., of 48, Lombard-street, City, for "Improvements in the manufacture of astronomical and other clocks, chronometers, and watches."—Dec. 7.

John Hackett, of Leicester, for "Improvements in the manufacture of pill-boxes."—Dec. 7.

David William Wire, of 9, St. Swithin's-lane, London, gentleman, for "an Improved manufacture of candles and other like articles used for affording lights." (A communication.)—Dec. 15.

Henry Winter, of Webridge-gardens, Bark-place, Bayswater, Middlesex, for "Improvements in the manufacture of rope, cord, line, and twine." (A communication.)—Dec. 15.

George Ambroise Michant, of Epieds, France, but now of New Bond-street, Middlesex, gentleman, for "Improvements in the production and application of heat, and in the manufacture of coke."—Dec. 15.

William Maltby, of Tredegar-square, Mile-end, gentleman, and Thomas Webb, of Mare-street, Hackney, gentleman, for "certain Improvements in the manufacture of spirits from grain or other saccharine matters, and in the apparatus to be used therein."—Dec. 15.

William Westbrooke Squires, of 3, Rue Chaveau la Garde, Paris, M.D., for a mode or modes of producing a vacuum, which mode or modes may be applied to pneumatic, hydraulic, and hydrostatic apparatus, and to machinery for obtaining motive power."—Dec. 18.

Richard Wrighton, of Lower Brook-street, Grosvenor-square, Middlesex, for "Improvements in apparatus to be applied to railway carriages and engines."—Dec. 22.

Charles Andre Felix Rochaz, of Paris, for "certain Improvements in treating zinc ores, and in manufacturing oxide of zinc."—Dec. 22.

Pierre Augustus Puis, gentleman, of Paris, for "Improvements in apparatus for raising and lowering heavy bodies in mines." (Communication.)—Dec. 22.

Henry F. Baker, of Boston, United States of America, for "a certain new and usefu improvement in steam-boiler furnaces."—Dec. 22.

Richard Baird, of Dundee, Scotland, for "A new or improved method of communication between the guards, engine-drivers, and other servants in charge of trains of carriages and waggons on railways, and also between the passengers and engine-drivers, and other servants in charge of such trains."—Dec. 22.

Robert Stamp, of Chelsea, Middlesex, hatter, for "Improvements in the manufacture of fabrics to be used for covering hats, caps, and bonnets, which fabrics may be used for other articles of wearing apparel."—Dec. 22.

Charles William Siemens, of Manchester, engineer, for "Improvements in engines to be worked by steam and other fluids."—Dec. 22.

ARCHED TIMBER VIADUCTS.

PLATE III.

WILLINGTON & OUSE BURN VIADUCTS · NEWCASTLE & Nth SHIELDS RAILWAY.

Fig. 1.

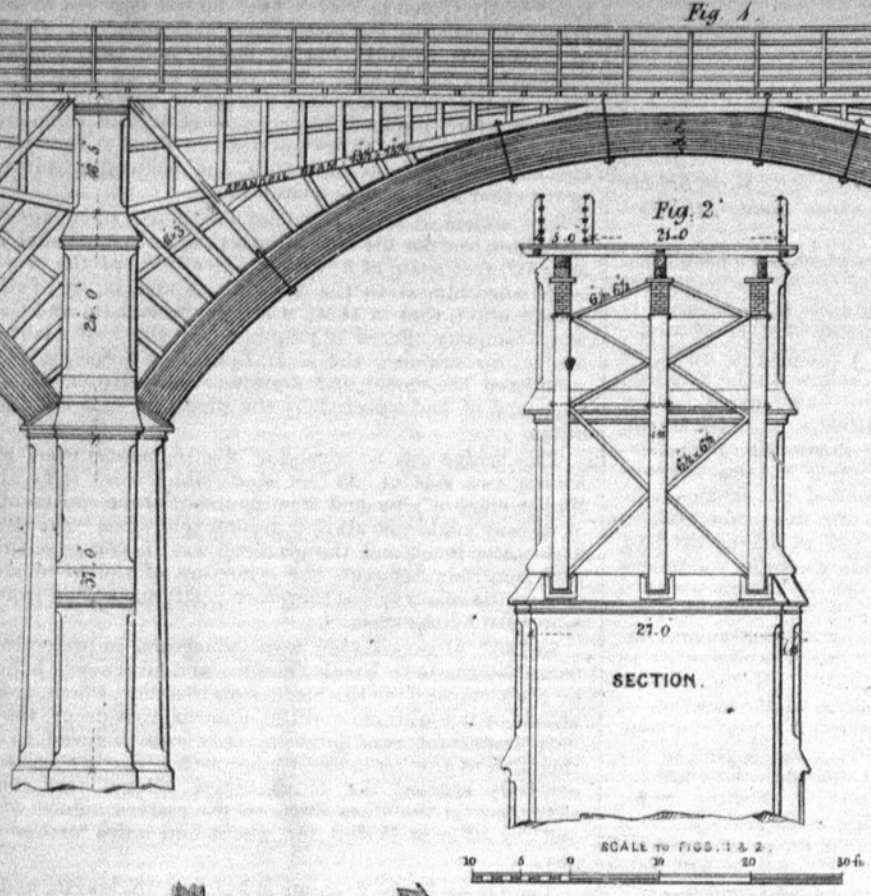
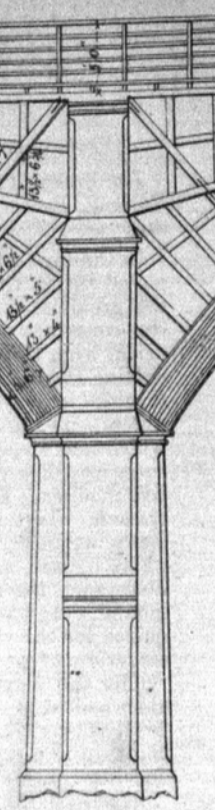


Fig. 2.



SCALE TO FIGS. 1 & 2.

30 5 0 10 20 30 ft.

Fig. 3.

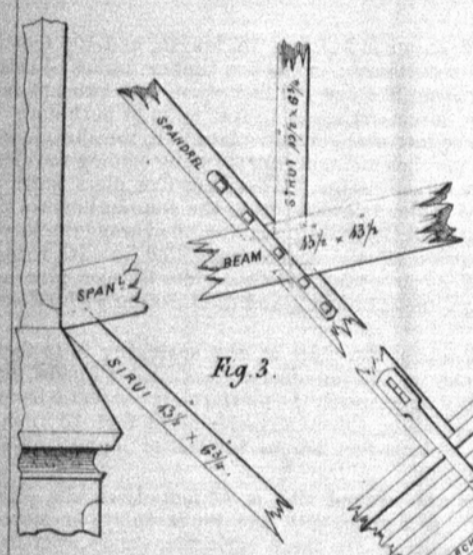


Fig. 4.

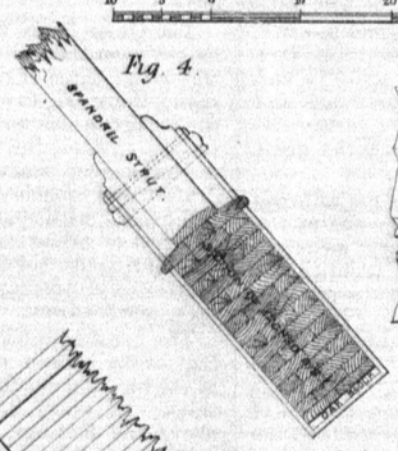


Fig. 5.

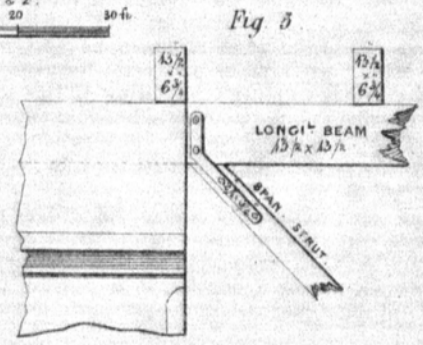
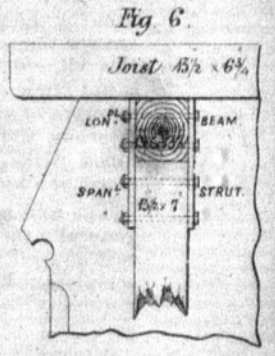


Fig. 6.



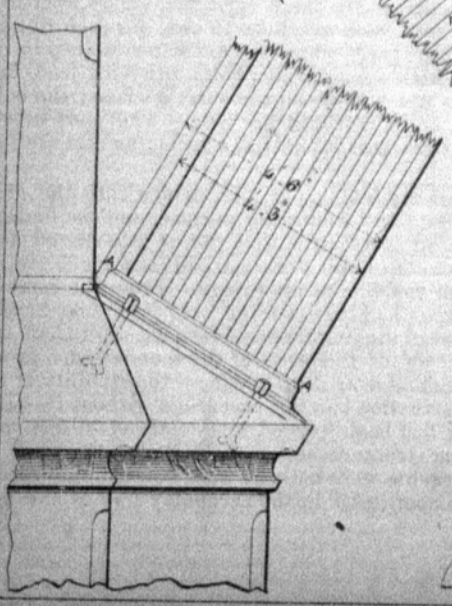


Fig. 7.

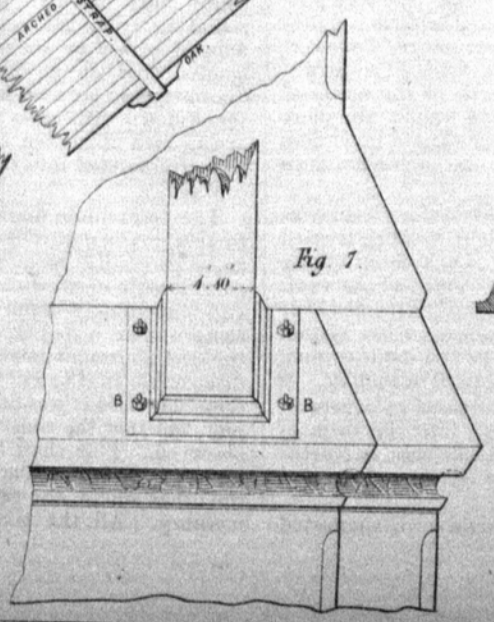


Fig. 8.

Fig. 9.

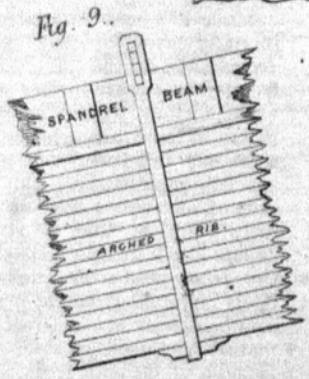
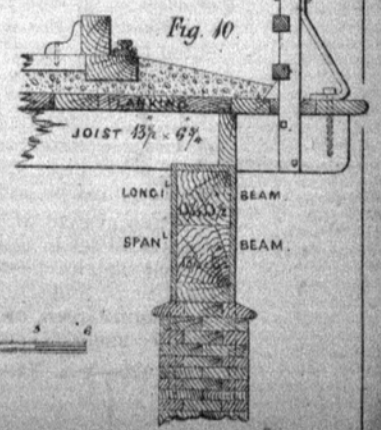
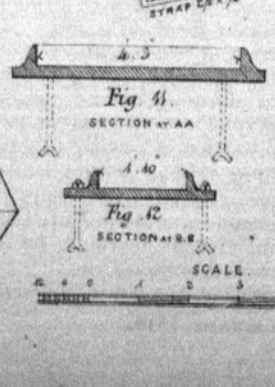


Fig. 10.





ARCHED TIMBER VIADUCTS.

(With Engravings, Plates III. and IV.)

(From papers read at the Institution of Civil Engineers.)

The Arched Timber Viaducts on the Newcastle and North Shields Railway, erected by Messrs. JOHN *and* BENJAMIN GREEN, *of Newcastle-upon-Tyne.*

In the formation of the numerous railways which have been completed within the last few years, perhaps that which has demanded the greatest exertion of skill, judgment, and varied ingenuity, is the construction of the bridges and viaducts, whether of stone, brick, iron, or timber. The excavation of a quantity of earth, or cutting through a hill to fill up an adjacent hollow to the required level, is in most cases a work of little more than manual labour, unless some unforeseen extraordinary difficulties occur in the strata, which may require energy and promptitude in adopting such measures as will overcome them in the most effectual and least expensive manner. But when rivers are to be spanned and ravines to be crossed, where there exist uncertain and variable beds, and, in many instances, in the vicinity of towns and populous districts, where houses, manufactories, and other buildings are on the immediate spot, the space required for filling up such ravines with a mound, (the base extending far on each side, beyond what is required for the width of the railway) would, by the consequent destruction of property, often involve such ruinous expenses, as to render the adoption of that method impracticable. Recourse must then be had to other and more scientific means, in the erection of bridges or viaducts, with piers occupying a small superficial area, built up to carry the necessary superstructure, and adapted to the locality in which they are placed. Various considerations are involved in fixing on a certain plan: yet the cost is that of the utmost importance, and invariably presents itself first in all great works of the kind. It will not be denied, therefore, that the great desideratum for the engineer, is the adoption of such means as will fully answer the purposes and the ends at which he aims, and to effect this without a waste of any kind of material; for every thing that is not fairly and usefully employed in adding to the stability and strength of an erection, can only be considered as superfluous and injurious matter; and fitness and a skilful disposition of parts, combined with correctness of design, may be said to form the great merit of all structures.

The cost of the construction of viaducts and bridges for railways generally forms so important an item in the gross amount of the cost of a railway, that the engineer is led to devise new means of completing his works in such a manner, as to possess stability and durability, without plunging his employers into unnecessary expenses.

Stone has been generally applied as the best material for bridges; in many cases, however, it cannot be used throughout, and in large arches, where the heights are too low for the spans, cast-iron is frequently adopted, and more particularly in forming trusses of various kinds, when the under side as well as the upper side of the platform is required to be horizontal, or nearly so, as in the case of a railway and turnpike-road crossing each other, and only leaving space enough between the surface of each to allow of the free passage of carriages; but the cost and weight of these bridges is generally equal to that of stone. A wood superstructure, however, effects much in this respect; provided a durable mode of construction is adopted; for the cheapness and strength of the material itself being so great, in proportion to its bulk and weight, the piers of a bridge or viaduct can be considerably lightened, and much less material be used in their formation than when the superstructure is to be of stone or iron.

Almost all the wooden bridges that have heretofore been executed in this country are constructed with straight timbers, trussed and framed like the ordinary forms of roofing. On account of the shrinking, from the number of joggles, and the weight of the work itself, the roadway sinks, and the framing generally becomes bent or crippled, often to an alarming extent; besides, such a system could never be carried beyond a certain extent, as the spans of such framing must be limited to what is usually practised in roofing.

A new system of building timber bridges, composed of layers of deals 3 inches in thickness, turned over a centre, into the form of arched ribs, has been introduced and applied extensively, in Northumberland and Durham, and in Scotland, by Messrs. John and Benjamin Green, of Newcastle-upon-Tyne.

This mode of constructing the laminated deal arch suggested itself to Mr. Green in 1827-8, when he was engaged in designing the bridge for crossing the river Tyne, at Scotswood: where the depth of water, its rapidity during floods, and the uncertainty of the foundations, would have rendered the construction of a number of piers, in the current, a very expensive operation, and Mr. Green was therefore induced to recommend to the company the chain bridge which is now thrown across the Tyne at that place, as being the cheapest durable structure, and possessing advantages over every other kind in such a situation.

The subject of wooden arches continued to engage Mr. Green's attention, and for his own satisfaction, he had a model made of an arch 120 feet span, at a scale of one-twelfth of the real size, which so satisfied him as to the advantages and safety of that mode of construction, that in 1834, when the Newcastle and Carlisle Railway Company offered a premium for the best plan of a railway bridge, for crossing the river Tyne, above Scotswood, Mr. Green submitted his model and design in competition, when they were approved of and selected by the directors, and obtained the premium.

This bridge was to consist of five segmental wood arches, each having two ribs of 120 feet span, which were to be erected upon timber piers of piles and framings, with stone abutments. The line of railway could not allow a greater elevation than 21 feet above high-water level, and the platform was in consequence suspended with iron rods between the springing of the wood arch and the crown; the roadway was therefore partly suspended from and partly supported by the ribs.

In 1833 Messrs. Green were concerned in projecting a railway from Newcastle to North Shields; and afterwards being employed by the Company for the bridges on that line, where, from the magnitude of two of them and the number that occur, the cost was a very important consideration, they were induced to recommend this plan of the laminated timber arch. Having made designs and carefully studied the details, these bridges were commenced in 1837; one at the Ouse Burn in the eastern suburb of Newcastle, and the other at Willington, about four miles further on the railway.

The OUSE BURN VIADUCT is 918 feet in length, and 108 feet in height from the bed of the burn; it has five timber arches of three ribs each; three of the arches are 116 feet span, and two 114 feet span; there are two stone arches of 40 feet span at both ends of the bridge, which were introduced to give length to the abutments, so as to prevent the mounds endangering them, by coming too close upon the steep banks of the ravine. There are five piers built of drafted and broached ashlar masonry, from the foundations to the full height, with spaces in the middle, leaving an average thickness of 5 feet of ashlar work; all the spaces are filled in with rubble masonry, made solid by grouting. On the sides of each pier are buttresses projecting 2 feet 11 inches, and diminishing with off-sets up to the roadway.

The greatest thickness of the piers at the springing is 15 feet; that of the highest pier at the foundation is 20 feet 3 inches, and at the top, immediately underneath the platform, it is 6 feet 6 inches thick; its width, including the buttresses, is 33 feet 10 inches above the footings, and 26 feet across the last or highest off-set underneath the roadway.

The springing for the arched ribs is 40 feet down the piers, where large off-sets are formed with the inner splays or slopes, radiating from the centre. On these springing stones, cast-iron flanged plates or sockets, each weighing 15 cwt. for each rib, are bedded with oakum, into spaces which are cut 2 inches deep in the masonry, and secured with wrought-iron bolts run with lead, fastened down with nuts and screws on the outer surface; the bolts are 1½ inch diameter, and 1 foot 9 inches long. The ends of the ribs are inserted into these iron sockets as a springing and are well caulked.

The two middle piers are built upon piles driven into the clay, to an average depth of 35 feet below the surface, and the foundations generally required great attention, for it was found that considerable excavations of old pit workings had been made around and immediately under the line of the bridge. From the extreme eastern pier, a coal seam had been worked out, extending beyond the east abutment; and in digging for the west pier, a pit shaft was discovered in the centre of the area of the foundation. It was fortunate that it was not so near as to endanger the stability of the pier, and that the construction had not proceeded without its being observed. This shaft had been worked to a depth of 70 feet, and in order to render the structure secure, both it and the seam on the other side of the ravine were built up with well grouted rubble masonry. All the timber used in the carpentry was of the best

quality from the Baltic, and the whole of it was subjected to the process of Kyan's patent.

The arched ribs are shown in Plate III., figs. 1 and 2; and in detail, figs. 3 to 12. The spans of 116 feet, have a versed sine of 33 feet, the radius being 68 feet. The ribs are constructed of Dantzic deck deals, 11 inches wide by 3 inches thick, dressed and cut to lengths of from 20 feet to 46 feet. The first course of the rib is two deals in width, bent over the centre, and the next is one whole and two half deals, and so on alternately until the wholé rib is formed; each rib consists of fourteen deals in thickness, exclusive of the weathering or capping on the top; the ends of the deals throughout are butted against each other, and arranged so that no two of the radiating joints may come together. A layer of strong brown paper dipped in boiling tar, is put between all the joints to bed them and to exclude the wet. The whole of the deals are well fixed together with the best 1½ inch oak trenails placed 4 feet apart, and each trenail is of a sufficient length to go through three thicknesses of the deals. The ends of the deals are all inserted into the cast-iron plates already described, bedded in patent felt and tar, and well caulked.

Diagonal side braces 6½ inches by 6½ inches, (shown in fig. 2, Plate III.), are fixed between the ribs with wrought-iron bars 1¼ inch diameter, at intervals of about 29 feet apart, to bind and connect the whole together. From the ribs, a series of radiating and horizontal struts, are carried up in the manner shown in the engravings; the ends of all the struts are double tenoned into proper mortices cut to receive them, in the timbers and ribs. A spandril beam 13½ inches square, (figs. 3, 4, 8, and 9, Plate III.,) is placed about the middle of the spandril, inclining upwards to the crown of the arch, and butting against a horizontal piece of the same dimensions at the top. The struts below this beam radiate to the centre, and those above are perpendicular to the roadway. One of the radiating struts in each spandril, called in the drawings the spandril strut, (figs. 5 and 6, Plate III.,) is continued on from the rib up to the longitudinal beams, and is firmly connected by iron straps and bolts to them and the spandril beams, and the former are then secured down to the masonry with iron bolts, which run 8 feet into the ashlar work. In considering this geometrical arrangement of strutting in the spandrils, it will be evident how much rigidity is produced: a weight coming upon one haunch of the arch is resisted on the opposite haunch, by the spandril strutting, and especially by the main strut, connected as it is with the weight of masonry laid hold of by the bolts, from the main longitudinal beam.

The longitudinal beams, 13½ inches square, are fixed and laid the full length of the structure, to the gradient of the railway, above which the joists, 13½ inches by 6¾ inches, are laid 4 feet apart from centre to centre, and spiked down upon them. The ends of all the joists are rounded, and project about 2 feet 6 inches over the longitudinal beams, fig. 10, and the whole are then covered with planking, 11 inches by 3 inches, laid longitudinally, and properly spiked down and caulked; this platform is then covered with a composition of boiling tar and lime, mixed with gravel whilst it is being laid on; thus forming a coating completely impervious to the wet. At the meeting of the longitudinal beam and the crown piece, an iron strap is bound over them and the longitudinal beam, and it is then run through the rib, and screwed up underneath it. Another strap is put round the rib and the spandril beam, about 12 feet further down on each side, and another at each of the spandril struts. An open railing, 5 feet high, is fixed alongside each side of the bridge, the upright standards are 8 feet apart, fixed to every alternate joist, and five horizontal rails, halved and spiked to them, run the full length.

The total width of the Ouse Burn Viaduct, measuring within the railing, is 26 feet, from which a footpath is taken, 5 feet wide, separated from the railway by a line of railing on the south side, as shown in fig. 2.

In constructing both the masonry and timber work of this viaduct, the scaffolding and the centering used were very light and simple. For the former, a temporary railway, 35 feet high, raised upon upright bearers, struts, &c., was laid the full length, on each side of the intended structure; and was afterwards raised, as the building proceeded, to within a few feet of the height of the finished platform. On this railway temporary cranes were placed, spanning from one rail to the other, connected at the top with beams of timber, and fitted up with proper winches, blocks, chains, &c. &c.; these cranes were generally worked by four men. The centering for turning the ribs and building all the timber work was exceedingly light; it was composed merely of three ribs, weighing about 18 cwt. each, or 2 tons 14 cwt. for each rib. A whole centre could be removed in a day from one arch, and fixed in its place for another arch, by about twenty men, employing the travelling cranes.

The WILLINGTON VIADUCT is precisely the same in construction and design as that at the Ouse Burn; but differs in its dimensions, and although it is not so high, it is longer, and has two more timber arches of greater span. The total length is 1050 feet, and the height is 82 feet. There are seven timber arches and six stone piers, with two stone abutments; five of the arches are 120 feet span each, and two 115 feet span each; the width between the railing on each side is 21 feet, being just sufficient for the double line of railway, as there is no footpath upon this viaduct. Two of the piers are built upon piles 36 feet long, at a depth of about 50 feet below the surface, as there is a great extent of alluvial deposit immediately on the site, which is frequently covered, during high tides or floods, by the river Tyne flowing up at the small burn.

Both these viaducts span over numerous houses and manufactories.

The method of building the viaduct at Willington was somewhat different from that adopted at the Ouse Burn, and perhaps not so unique; inasmuch as there were no travelling cranes or temporary railway, and the removal of the centres was attended with greater labour, for while at the Ouse Burn the removal of a centre occupied twenty men, with the cranes, only one day, the same work employed twenty men for ten days at Willington. The masonry of each pier was set with a fixed or jib crane, of a sufficient height to hoist all the stones, having the usual counterbalance at the opposite end of the horizontal beam.

In this system of timber bridge building, the straight trussing in the main principle of support, is dispensed with, for the spandril framing should not be looked upon as partaking of that character; it is merely a continuation of the wood-work, to convey the weight coming upon the roadway, on to the simple curved rib, and all timbers in a state of tension are avoided, for when a weight comes upon the roadway, the whole of the structure undergoes compression.

It is not meant to advocate timber bridges on this or any principle in preference to stone, or other more durable material; but it will not be denied, that the great saving of capital in the first instance is a very important argument in favour of their adoption.

The actual cost of the Ouse Burn Viaduct, including all contingencies and extras, was:—for the masonry, 17,235*l.*; for the carpentry, 7,265*l.*; making together, 24,500*l.*

The total cost of the Willington Viaduct, was:—masonry, 13,153*l.*; carpentry, 10,349*l.*; together, 23,502*l.*

The piers, Mr. Green observes, are stronger than necessary for the weight of the superstructure, for the directors of the Newcastle and North Shields Railway not only being sceptical as to the safety of this novel mode of construction, but having a desire to finish all the bridges on the line with stone arches, wished the masonry to be made of such solidity and bulk as to bear stone arches if required, and the piers and abutments were, therefore, built accordingly. The additional cost for building stone arches, however, on a fair calculation, was found to amount to 9,000*l.* for the Ouse Burn Viaduct, which would have made a total of 33,500*l.* The centering would have cost at least 3,000*l.* for each viaduct, so that at a moderate calculation the actual saving of capital is upwards of 10,000*l.*

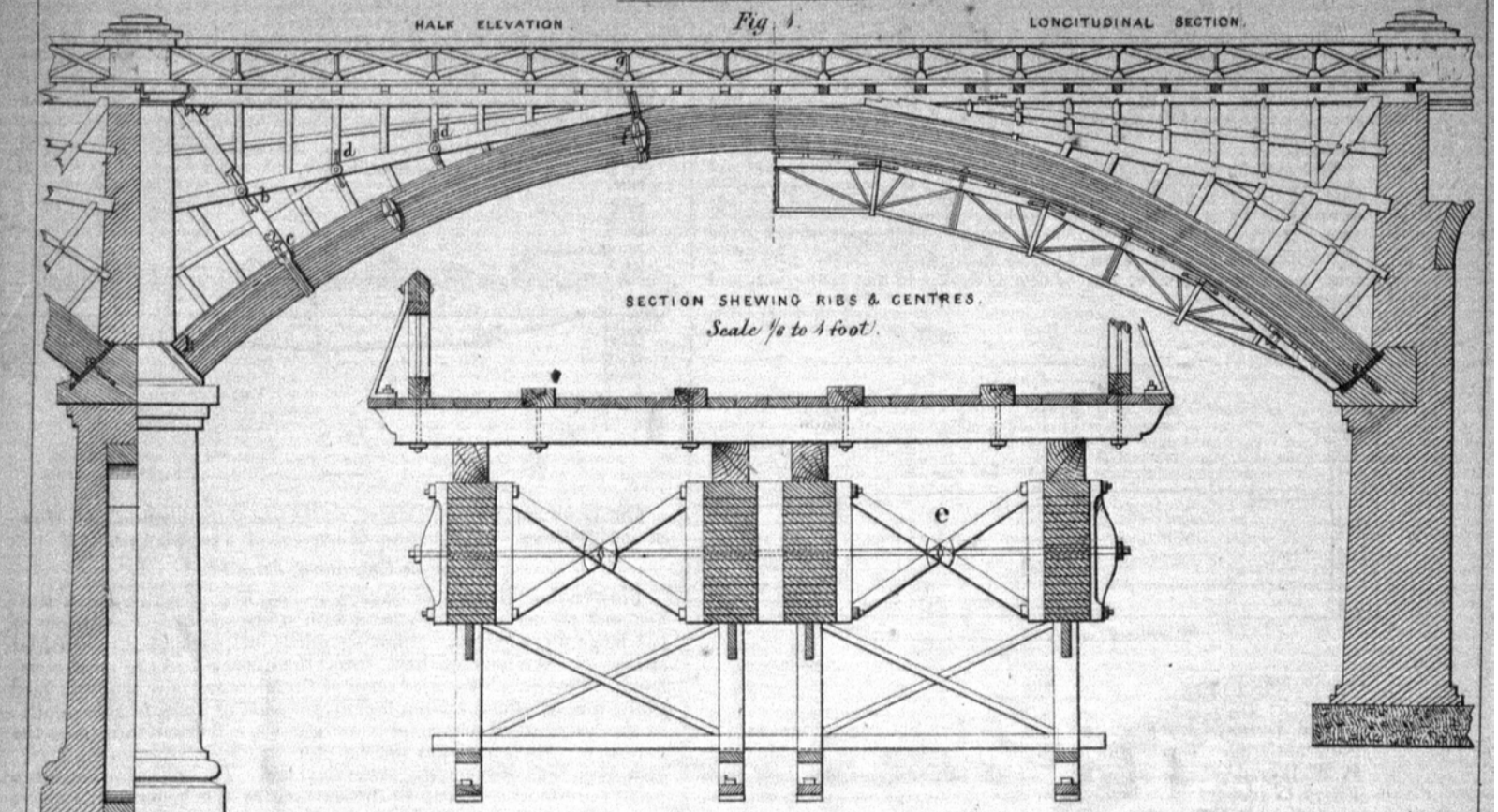
Messrs. Green have just completed a large viaduct, on precisely the same principle as those of the Ouse Burn and Willington Dean, for his grace the Duke of Buccleuch, across the South Esk at Dalkeith, in connexion with the Edinburgh and Dalkeith Railway, and for the transit of coal from the collieries of his grace in that neighbourhood; it has only a single line of railway and a footpath. The total length of this work is 830 feet, the height is 87 feet to the platform, and the width across between the railing is 14 feet. It has seven arches, five of 120 feet, and two of 110 feet span each, with a versed sine of 30 feet. There are only two ribs, 8 feet 4 inches apart, in each arch, and of a deal and a half (1 foot 4 inches) in width, and ten deals (2 feet 7 inches) in depth. The longitudinal beams are half balks of timber, 13½ inches by 6¾ inches. There are two stone abutments, each 40 feet long, and five stone piers. The largest pier is 91 feet high from the foundation, which is 5 feet below the surface. All the piers are 10 feet thick at the springing, 12 feet 10 inches wide, and 5 feet 4 inches thick at the top, underneath the roadway. The total cost was:—masonry, 3,617*l.*; carpentry, 3,358*l.*; together, 6,975*l.*, which is a very small amount for a work of such magnitude.

ARCHED TIMBER VIADUCTS.

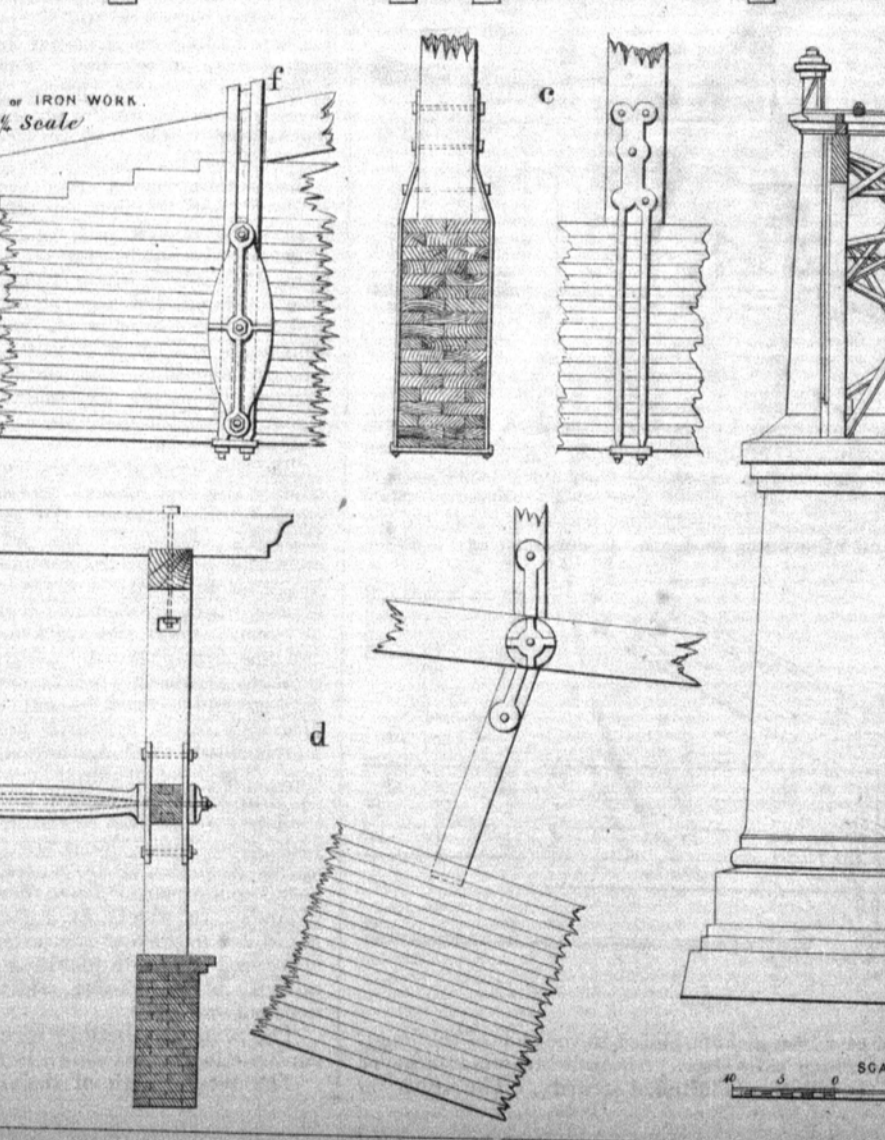
PLATE IV.

DINTING VALE VIADUCT.

HALF ELEVATION. *Fig. 1.* LONGITUDINAL SECTION.



SECTION SHEWING RIBS & CENTRES.
Scale ⅛ to 1 foot.



DETAILS of IRON WORK.
½ Scale

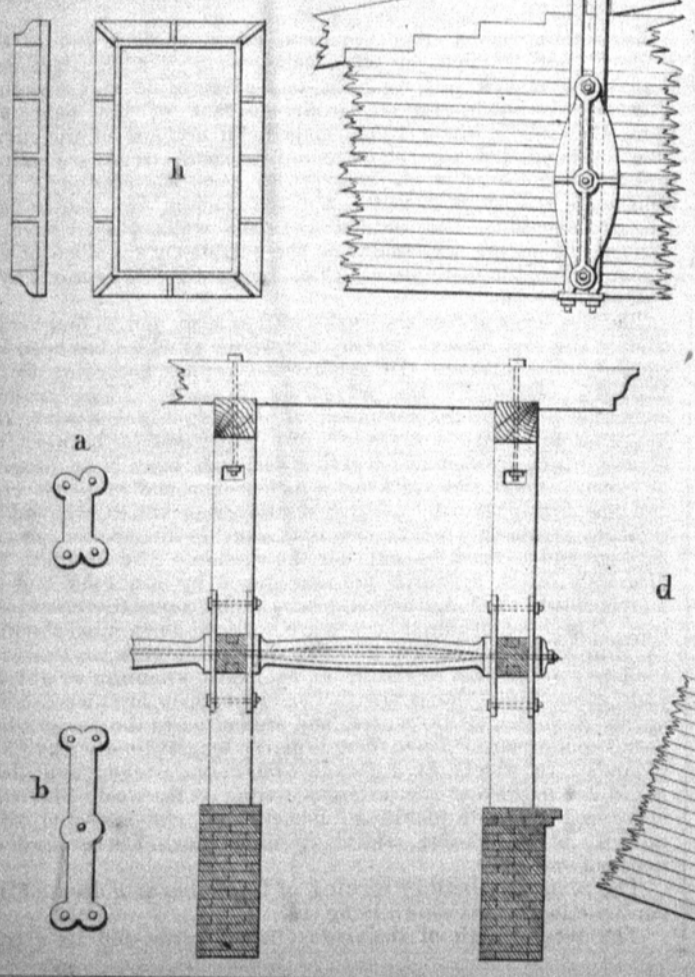
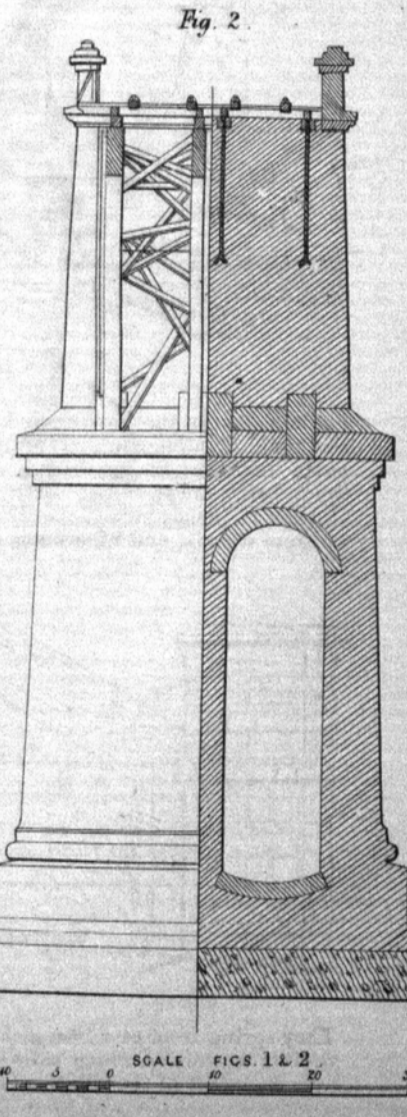


Fig. 2.



SCALE FIGS. 1 & 2

The great height and length of this bridge, and the extreme lightness of its construction, render it an imposing object, spanning a beautiful and thickly wooded ravine near Dalkeith Palace, with the river Esk streaming through it, and appearing as a mere line of water in passing under the centre arch, which is the largest and highest.

The system of arching with planks, may be carried to almost any extent, and in Messrs. Green's design for the proposed bridge across the Tyne, to connect the towns of Newcastle and Gateshead, at a high level, the largest arch over the middle part of the river was intended to have been 280 feet span, with a versed sine of 70 feet, the total length of the bridge as designed was 1,220 feet, and the height 110 feet.

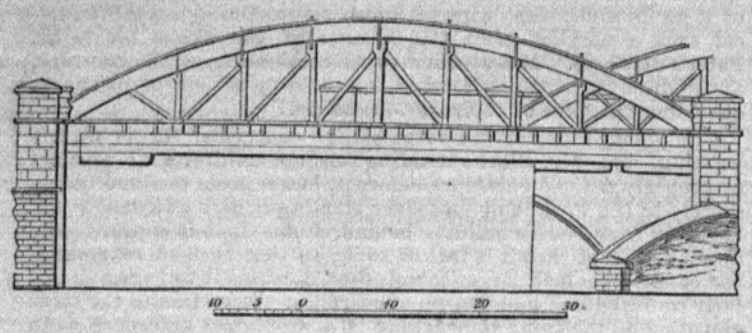


Fig. 1.

The annexed wood engravings show an oblique bridge on the Newcastle and North Shields Railway, crossing the Shields road, at Walker. The angle of the skew is 25°, and the span is 71 feet. Fig. 1 is an external elevation of one of the ribs and the piers, and

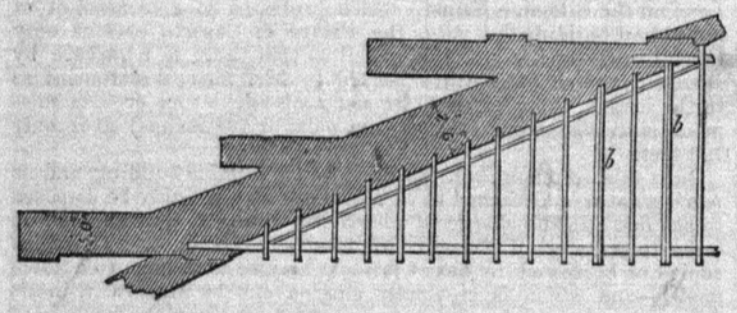


Fig. 2.

fig. 2, a plan of the joisting and piers. The joists of the platform rest upon the longitudinal beams, which are suspended by queen posts and iron straps, from two arched ribs, one on each side of the railway, and stiffened by struts and braces. The ribs are formed of deals 11 inches by 3 inches, dressed one deal and a half for the width of the rib, and nine deals in depth, as shown in figs. 3 and 4.

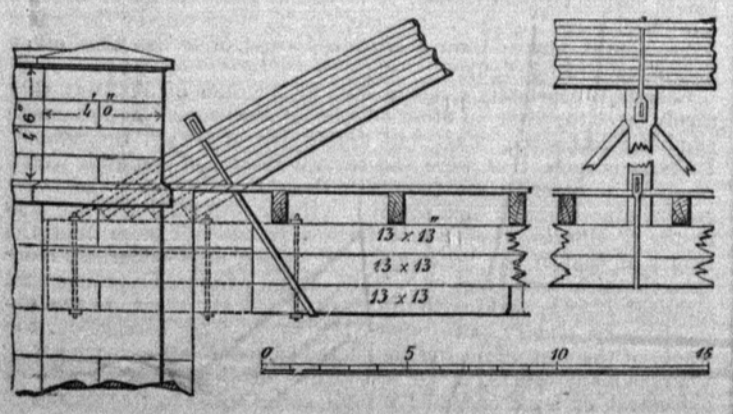


Fig. 3.

They spring from cast-iron sockets, bolted to the ends of the longitudinal beams, on which they abut. An iron strap is also keyed over each foot of the ribs, for additional security. The width for the railway on the bridge is 21 feet 6 inches. In the centre, at intervals of about 7 feet, the platform is strengthened by trusses, which are marked *b b*, fig. 2, and constructed in the manner shown in fig. 4, with wrought-iron bars keyed at the ends of the beams, and coming underneath, having three iron bearers in the full length. The cost of this bridge was about 1,300*l*.

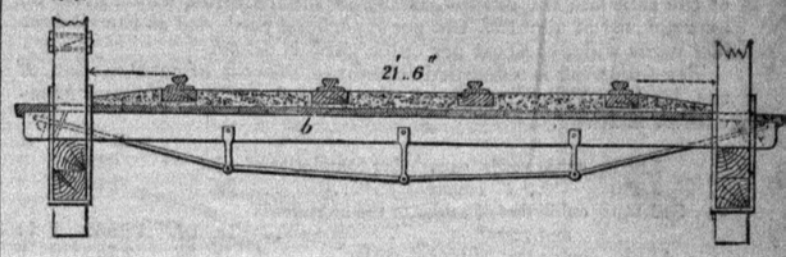


Fig. 4.

The Dinting Vale Viaduct, *on the line of the Sheffield and Manchester Railway.* By Alfred Stanistreet Jee, M. Inst. C.E

(With an Engraving, Plate IV.)

This viaduct consists of sixteen arches, five of which are of timber and eleven of brick, faced with stone quoins. The whole of the large piers, wings, outside spandrils and parapets, are of ashlar stone, of excellent quality, from the quarries in the neighbourhood. The foundations of some of the piers are laid upon the hard shale, and of others upon a bed of wet sand of considerable depth; in the latter cases masses of concrete were formed to receive the masonry. Several of the smaller piers are founded upon the marl; also with beds of concrete beneath them. The piers for the large arches are built solid, up to the surface of the ground, and above that level they are hollow, nearly up to the impost; the hollow portion having an inverted arch at the bottom, and being also arched over at the top. The portion above the impost in the large piers is solid to the top, (see fig. 3.) The smaller piers are cased with ashlar on the outside, and are filled in solid with good flat-bedded rubble, well grouted, and with through stones at intervals of 6 feet horizontally in each course.

The smaller semicircular arches of brick, at each end of the viaduct, are 50 feet in the span and 3 feet in thickness, with stone quoins, and are built in a curve of 40 chains radius. The face of each pier is parallel to that of the next, the piers themselves being wedge-shaped, on account of the curve. The abutments between the large and the small arches are hollow and are arched over in the interior, to carry the roadway. The abutments and wings at each end of the viaduct, are also hollow, being composed of longitudinal and cross walls, flagged over on the top. They are surrounded on the outside by the slope of the embankment, the material of which being clay, is kept out by a wall at the ends.

The five large arches are each 125 feet span and 25 feet versed sine, of the best Memel timber, the whole of which has been immersed in a solution of the sulphate of copper, according to Dr. Margary's patent, for the prevention of decay. There are four main ribs in each arch, composed of planking 3 inches thick, laid longitudinally, with a layer of brown paper and tar between the planks, which are fastened together with oak trenails at intervals of 4 feet. These ribs are 4 feet 6 inches deep, and 18 inches wide, and are firmly stayed by diagonal and cross braces, screwed up tight, by means of wrought-iron rods, 2 inches in diameter, passing through and secured by nuts on the outside. The uprights and diagonals in the spandrils are also stayed by iron rods, and are morticed into the longitudinal beams which carry the cross joisting. These longitudinal beams are fastened down upon the piers by iron bolts, let 12 feet into the solid stonework, to resist any tendency of the arch to rise in the haunches, when the weight of a train comes upon the centre. The cross joists are placed 5 feet apart, from centre to centre, and are bolted to the longitudinal beams underneath. Upon them is placed longitudinally a half balk of timber, to which the rails and chairs are fastened, and also a guard rail to prevent the carriages getting off the road. The whole is covered over with planking 3 inches thick, and is coated with a mixture of lime, ashes, and sharp sand, which has set hard and does not crack.

The centering used for turning of the arches is of iron, of light construction, and is shown in fig. 1.

The total length of the viaduct is 484 yards, and its greatest

height from the brook-course to the rails, is about 125 feet. The roadway is level throughout. It was commenced early in 1843, and was opened for traffic on the 8th of August, 1844. Messrs. Buxton and Clarke, of Sheffield, were the contractors, and great credit is due to them for the very excellent manner in which they have completed the work.

The area of the section of the valley crossed, between the level of the rails and the ground, is 13,068 square yards, which gives an average cost of about 2*l.* 14*s.* per superficial yard, and as the viaduct is 8 yards wide, the cost per cubic yard is 6*s.* 9*d.*

The following is a detailed account of the cost of construction of the Dinting Vale Viaduct, on the line of the Sheffield and Manchester Railway.

			£	*s.*	*d.*
7,881	cubic yards, excavating foundations	7*d.*	229	17	3
2,000	,, concrete	3*s.* 6*d.*	350	0	0
342,155	cubic feet of ashlar in the abutments and piers	1*s.* 1*d.*	18,532	7	11
44,024	cubic feet of tooled ashlar ..	1*s.* 3*d.*	2,761	10	0
829	,, cornice	1*s.* 6*d.*	62	3	6
8,212	,, parapet walls ..	1*s.* 1*d.*	444	16	4
6,875	,, flagging over spandrils	10*d.*	286	9	2
2,574	cubic yards of coursed rubble, in the small piers	10*s.*	1,287	0	0
	Puddling the small arches ..		37	13	0
2,641	cubic yards of brickwork in the arches	15*s.*	1,980	15	0
40,476½	cubic feet of Memel timber ..	3*s.*	6,071	9	6
18,285	superficial feet of planking in the roadway	8*d.*	609	11	8
	Centering	..	600	0	0
Tons. Cwt. Qrs.					
32 4 1	wrought-iron	£21	676	5	3
31 2 0	cast-iron	£8	252	0	0
73,260	superficial feet of brown paper and tar	½*d.*	152	4	0
2,031	superficial yards of concrete on the roadway	1*s.* 6*d.*	152	6	0
	Patent felt	..	3	15	0
	Laying the permanent road ..	..	408	6	6
	Diverting the mill goit ..	..	110	16	8
	Interest and maintenance for 12 months	..	240	19	8
		Total cost	£35,250	6	5

THE RIVAL PALACES,

OR, BLORE'S AND VANVITELLI'S.

By CANDIDUS.

Neither Mr. Sharp himself nor any one else will be at all surprised at *my* taking some notice of the oversight imputed by him to those who have spoken of Buckingham Palace, for not discovering that it is "only a reduced copy of the Palace at Caserta." Willing as I am to accept the compliment of "lynx-eyed," I think that in this instance it rather belongs to him, though at the same time I fancy his *sharp*-sightedness has overshot the mark, and made that kind of discovery which is called finding out a mare's nest. What appears to Mr. Sharp to be such perfect similarity of design between the two buildings, that all the faults or merits of Mr. Blore's fairly belong to Vanvitelli, completely vanishes upon a critical examination and estimate of them, nothing remaining but that general or generic resemblance of forms and features which they possess in common with many other buildings in the same style. Those who talk merely at random might perhaps liken Buckingham Palace to that at Caserta, for much stranger resemblances have been fancied ere now,—one traveller having likened the palace of Charles V. in the Alhambra, to Jones's Whitehall; and another, the great temple at Balbec to St. Paul's, Covent-garden! But that an architect should be more struck by the resemblance, such as it is, than by the prodigious difference between the two buildings in question, is quite astonishing.

Let us inquire to what the resemblance amounts:—to nothing more than the general disposition of parts, both vertically and horizontally, which surely is not sufficient to constitute such similarity of design or character as to justify our calling the one a copy at all, much less "only" a reduced copy of the other. If it does, we should be warranted in setting down all the porticoes ever erected as only so many verbatim transcripts of one original; or we might call—as perhaps Mr. Sharp does—the two terraces at Carlton-gardens a copy of the Garde-meuble in the Place de la Concorde. In fact, it requires Fluellen's ingenuity in arguing to convict Mr. Blore of being, I will not say Vanvitelli's ape, but his Dromio. "There is a river in Macedon," says the Welshman, "and there is also moreover a river at Monmouth;—and there is salmons in both." Even were Mr. Blore's elevation a mere reduced draught of the other, as far as what actual resemblance there is between them extends, as a copy it could be received only as an exceedingly maimed and imperfect one, some of the most striking parts of the original being altogether omitted. One exceedingly important accompaniment to the edifice at Caserta, and which gives it an air of completeness and consistently-kept-up stateliness in regard to *emplacement*, greatly surpassing that of any other royal palace in Europe, is the spacious oval piazza in front of it on its south side, where it forms an expanding amphitheatrical area, somewhat after the manner of the piazza before St. Peter's at Rome. Many other royal residences, on the contrary, are so disadvantageously located, as to have an air of meanness *about* them in spite of their own grandeur.

One point, then, of the resemblance contended for is utterly wanting, since Mr. Blore's building has no architectural precinct or properly defined enclosure before it, but is made to stand immediately in the Park, and moreover stands out very awkwardly and abruptly from Nash's building behind, from which it appears quite distinct, except that it is tacked to it; so that instead of making the entire mass look larger than before, it causes it to have a singularly confused and huddled-up appearance. Even taking the mere elevation of the front alone, there is a prodigious difference as to outline, the angles of the building at Caserta being carried up much loftier than the general mass, by the addition of a second order, comprising two stories, and making the entire height there not less than *one hundred and ninety* English feet. My calculation is from the scale given in the large work containing plans, &c., of the palace, entitled "Dichiarazone dei Disegni del Reale Palazzo di Caserta, &c.," and which, strange to say, is not mentioned by either Milizia or Quatremère de Quincy. In the "Conversations-Lexicon für Bildende Kunst," which professes to give account of individual buildings of note, the Palace of Caserta obtains only three lines!—one of which is to tell us that there is a picture by Mengs in the chapel.—With regard to Mr. Sharp's statement as to the length, there seems to be some miscalculation or else misprint, since 918 palms (taking the palm at 10⅓ inches) give only 790 feet.

Now that so much fault has been found with his building, and no merit whatever discerned in it, Mr. Blore may possibly be disposed to acquiesce in the charge of plagiarism brought against him, in order to transfer all blame from himself to Vanvitelli. If he has copied or borrowed, he has at least, it may be said, gone to a noble model—one which is especially singled out by Mr. Gwilt, in his "Encyclopædia of Architecture," as the most complete example of a royal palace. So far, however, from reconciling us to Mr. Blore's work, by what may be thought to afford sufficient precedent for one or two objectionable points, Caserta—any comparison with or even mention of it—is likely to put us more out of conceit with it than ever. By diminishing the scale so very greatly, Mr. Blore has exaggerated the defects and entirely missed all the merits of his supposed original, transmuting grandiosity into insignificance and triviality. In the mere design of Caserta, there is little to excite particular admiration: it is one of those things of which a "reduced copy," however accurate, can no more convey the actual impression it makes than a life-sized copy of it can that of an enormous colossal figure.

Caserta is especially distinguished by a union of qualities that rarely meet together in other edifices of the same class—namely, emphatic vastness of mass and uniformity of design throughout. Its mass is such, that were the several ranges of building which compose its exterior, together with those that separate the inner courts, placed beside each other on a single line, similar to the plan of the Tuilleries, they would form a façade full three times the length of that of the last-mentioned palace, or considerably more than three thousand feet in extent. What enhances astonishment, although it adds nothing to the merit of the structure, is the extraordinary energy with which the works were carried on, the whole of the vast pile being completed in about half-a-dozen years; whereas many others, of far less magnitude, have either grown up piecemeal, or have occupied a long series of years; so as not to have been begun and terminated by the same architect.

From the way in which Mr. Sharp has expressed himself, it seems to be his opinion that—the similarity of design which he insists upon being admitted,—Blore's façade so fairly represents